Listen to the Family

The Case

Vascular surgery was consulted for placement of a dialysis catheter in a patient on the medical floor. The surgical resident examined the patient, an elderly woman with dementia and renal insufficiency receiving IV hydration. The resident called the family to obtain informed consent for the procedure. The daughter was very surprised by the call, stating that no one had discussed initiating dialysis; she insisted that it was a mistake. The surgical resident attempted to convince the daughter that the patient's life was in danger, but the daughter refused to give consent. The next morning, the surgeon returned to the bedside, where the family again refused to provide consent. The medical attending caring for the patient was ultimately called, and he verified that the patient had prerenal azotemia related to dehydration. He was unaware of any request for dialysis catheter placement in this patient. Because they were worried about her safety, the family signed the patient out of the hospital and returned her to the nursing home. Upon further review, the catheter placement request was for another patient on the same floor with the same unusual last name, who had chronic renal failure progressing towards dialysis.

Dangerous Dapsone

The Case

A 78-year-old woman with newly diagnosed multiple myeloma on corticosteroids presented to the emergency department with dyspnea. Upon admission, she was found to be hypoxic, and she required increasing amounts of oxygen to maintain saturations greater than 90%. However, her arterial blood gas (ABG) showed a paO2 of > 430 on 100% O2, with no A-a (alveolar-arterial) gradient. The next day, she was found to be cyanotic on morning rounds, and a stat ABG showed methemoglobinemia of 30%.

The etiology of her methemoglobinemia was determined to be incorrectly dosed dapsone for *Pneumocystis carinii* pneumonia (PCP) prophylaxis. The patient had seen her oncologist the week before admission, who had erroneously written her dapsone prescription as "100 mg TID", instead of TIW (Mondays, Wednesdays, and Fridays). Of note, on admission, the inpatient pharmacy had called the admitting team about the inappropriately dosed dapsone. However, because the patient's family had a copy of the original prescription from the oncologist, the admitting team assumed that the dose was correct and rewrote the medication order at the erroneously high dose. Fortunately for this patient, this mistake did not cause her adverse long-term clinical consequences. Once the error was discovered, the patient was

promptly started on cimetidine 300 mg IV daily, and her methemoglobinemia resolved 7 days after admission.

Too Tight Control

Case & Commentary: Part 1

A 28-year-old man with insulin-dependent diabetes mellitus was admitted with hyperglycemia and an infected foot ulcer. Due to new hospital initiatives aimed at tighter glucose control, he was started on an insulin drip rather than subcutaneous insulin. The patient eventually required 8 units of regular insulin per hour to maintain a fingerstick glucose in the 180-220 mg/dL range.

Traditionally, only patients hospitalized for acute decompensation of diabetes were treated with intravenous (IV) insulin drips. More recently, intensive IV insulin therapy is being used in post-surgical patients for whom diabetes or hyperglycemia is a co-morbid, rather than a primary, condition. Emerging literature supports this new approach. In one study, the wound infection rate was reduced from 3% to 1% using a nurse-managed IV insulin protocol targeted to keep blood glucose less than 200 mg/dL for 72 hours after heart surgery.(1) In another, 1500 critically ill surgical patients were randomized to intensive (IV drip for blood glucose > 110 mg/dL, goal 80-110 mg/dL) and traditional (IV insulin reserved for blood glucose > 215 mg/dL) treatment of hyperglycemia.(2) The intensively treated group had about 50% lower ICU and hospital mortality rates, shorter hospital stays, and less morbidity. Although a few episodes of hypoglycemia were noted in the intensively managed group, there were no serious complications. These studies have generated a new consensus regarding the benefits of tighter glucose control in surgical ICU patients.

Given these results, and other studies demonstrating that hyperglycemia greater than 200 mg/dL is associated with more infections in patients undergoing "clean" surgery and in outpatients (and in vitro studies that show that ambient glucose over 200 mg/dL reduces macrophage migration and phagocytosis [3,4]), it is tempting to extrapolate that tight control will benefit medical, and not just surgical, inpatients. However, there are no data to support this extrapolation. Without demonstrated benefit in these broader populations, any efforts to improve glycemic control in such patients (including the one presented here) must place a premium on safety.

In non-critically ill hospitalized patients with hyperglycemia, subcutaneous insulin may be safer than an IV insulin drip. Physiologic insulin replacement requires a basal (delayed or extended absorption) form of insulin, especially for insulin-dependent (type 1) diabetes. This basal insulin is supplemented before meals with fast-acting insulin. New insulin analogues (such as insulin

glargine [Lantus], insulin aspart [Novolog] and insulin lispro [Humalog]) meet both basal and mealtime insulin needs. For example, a once-daily dose of insulin glargine will meet the basal requirement and need not be held or adjusted for NPO status; whereas, doses of insulin aspart or insulin lispro will meet mealtime requirements and are easily adjusted for the patient's nutritional intake. Since the physiologic attractiveness of using subcutaneous insulin in the non-ICU patient now conflicts with the potentially generalizable benefits of IV insulin drips seen in the ICU, we believe that we are at equipoise, and thus the two methods should be compared in randomized trials.

Case & Commentary: Part 2

On hospital day 2, the patient was evaluated by an orthopedic surgeon, who decided the wound needed surgical debridement. The orthopedic resident notified the cross-covering medicine resident that the patient would be taken to the operating room (OR) the following day. In preparation for the operation, the orthopedic service made the patient "NPO after midnight." At 2 am, when the nurse came to measure the hourly fingerstick, she found the patient somnolent, tremulous, and diaphoretic. His fingerstick glucose was 20 mg/dL.

Hypoglycemia is the most common complication of any insulin therapy and is an extremely frequent adverse event in hospitals worldwide.(5) In the perioperative population, oral intake is highly variable; patients receiving insulin therapy are at particularly high risk for hypoglycemia in this period. Broader use of insulin drips outside the ICU requires that safeguards be put in place to prevent a potential increase in the frequency of hypoglycemia. The clinical trials cited used strict protocols (1,2); most hospitals do not have such guidelines in place (H.R.R., unpublished data, 2004). Protocols for insulin drips should be created, which clearly outline proper adjustment of the drip at specific glucose levels, alterations in rate and IV fluid type if the patient is NPO, and frequency of glucose monitoring.(6,7) Automated orders and preprinted order sheets have been effective in reducing chemotherapy-dosing errors and in ensuring appropriate therapy for myocardial infarction in the emergency department.(8,9) Such interventions could be instituted for insulin dosing. Where computerized physician order entry (CPOE) and computerized medication administration records are available, standard orders could be brought to the screen whenever a patient with diabetes is admitted or an insulin drip is ordered or begun.

Without seeing the specific insulin drip order in this case, it is difficult to know how it might have been improved to avoid the adverse event. However, carefully developed decision support, to assist in adjusting insulin drips, and standardization of glucose monitoring in patients on IV insulin drips might have helped prevent this error. In an even more robust system of decision

support, both orders (NPO status and insulin therapy) would have been entered into a CPOE system and adjustments suggested automatically. A pop-up flag could have alerted the surgeon to ensure the insulin drip was appropriate for the situation, or that the primary care physician be notified. Finally, one can even envision a "forcing function," in which IV insulin is automatically discontinued, or a dextrose drip started, when an NPO order is written (with the physician immediately notified), further decreasing the chance of a mistake harming a patient.(10)

Results obtained in clinical trials often achieve rates of adverse events lower than those found in routine clinical practice. There are several reasons for these differences. First, patients in day-to-day practice are rarely monitored as closely as those in trials. Secondly, clinicians may administer therapies to patients who would have been excluded from trials.(11). This broadening of inclusion criteria can lead to a lesser benefit in actual practice, an issue known as the difference between the "efficacy" vs. "effectiveness" of an intervention.(11-14) We believe that it will be important for the safety literature to distinguish between patient harm in a clinical trial vs. "practical safety"—that which can be expected in real world practice.

In this case, the orthopedic surgeon wrote the NPO order, and did not notice the insulin drip. Allowing consulting services to write orders on patients may lead to poor communication, which can then result in errors and poor outcomes (15): through delays in diagnosis, unnecessary or duplicative diagnostic tests, delays in needed treatment, or unnecessary treatment. In the absence of "smart" information systems, it may be helpful to provide a procedural forcing function. For example, a hospital policy might require that the primary physician approve all new orders (obviously, such a policy will raise important staffing issues). The widely adopted hospitalist model (16) may reduce the potential for error that results from multiple physicians writing orders, as hospitalist services can be designated to write all orders on inpatients.

Case & Commentary: Part 3

The patient was treated with 1 amp of D50 and his insulin drip was held. He recovered completely from this event.

Increasingly, quality improvement efforts focus on decreasing the extent of "underuse" of effective therapies. However, even as we focus on ensuring that such therapies are uniformly used, we must remember that harm can result if no protocols or systems are in place to help monitor for and prevent their common side effects. Quality improvement efforts, exemplified by those of the Institute for Healthcare Improvement in its "Breakthrough Collaboratives" (17), suggest that a single, central outcome should be monitored to help make

quality improvement projects practical and do-able. Some refer to this as "moving the dot," derived from the popular run chart illustrating changes over time in a particular parameter.(18)

Assuming that "the dot" was the level of glucose control, this case sounds a cautionary note regarding such an approach. When our quality and safety improvement projects focus on correcting underuse of particular medications or therapies, we must carefully consider adverse events that may be increased by promoting a particular treatment, and implement safeguards to avoid them. Like physicians, quality improvement professionals will serve patients best if we focus on the Hippocratic mantra of *primum non nocere*: first, do no harm.

No Blood, Please

The Case

A young woman, about 30 years of age, was injured in an automobile collision. She was brought to the emergency department (ED) via ambulance, where she was found to be suffering internal bleeding with life threatening blood loss. After examination, physicians advised her that without transfusion of one to two units of blood within a very short time, she would die. The patient refused the transfusion, stating that her religion forbids it and that she understood the consequences. The ED staff deemed her to be competent and was ready to comply with her wishes.

At about the same time that she was undergoing examination, both her parents and her minister arrived. The parents asserted that their daughter had recently converted to her new faith only weeks before and therefore did not fully understand why the religion forbids blood transfusion nor the consequences of her decision. The minister, on the other hand, stated that the woman converted to this religion with the full knowledge of its tenets and was well aware of the consequences of her decision. He stated that, at the time of her conversion, she swore an oath that she would live by the tenets of the faith; that oath contained language forbidding blood transfusions. As these discussions unfolded, the woman lost consciousness. The ED staff reversed their previous decision, and transfused two units of blood into the unconscious woman. She was then taken to surgery.

The woman recovered from her injuries. She and the minister of her church sued the hospital generally and ED staff specifically. The judgment ruled in her favor, saying that the hospital and ED staff violated her civil rights and interfered with her ability to make her own decisions.

Do Me a Favor

The Case

A 26-year-old gravida 4 para 1 woman reported that her last menstrual period was 5 weeks prior, and she had a positive home pregnancy test. With a history of one ectopic pregnancy, one normal vaginal delivery, and one spontaneous abortion (miscarriage) at 6 weeks, she was concerned about a repeat ectopic pregnancy. The patient was a nurse who worked at the hospital and was friends with one of the obstetrics/gynecology residents. She asked the resident to perform a transvaginal ultrasound to check for an intrauterine pregnancy and rule out an ectopic pregnancy.

The resident brought the patient into the antenatal testing room without notifying the nursing staff or registering the patient. A transvaginal ultrasound was done, which did find an intrauterine pregnancy; neither the findings nor the patient's condition was documented in the medical record. The vaginal probe was not cleaned appropriately after the procedure.

The charge nurse on the floor noticed that the bed in the antenatal testing room had been used. On inquiry, she could not find a patient who had been admitted to that room. Ultimately, she asked the resident, who revealed that he had scanned his friend.

Privacy Gone Awry

The Case

A 3-year-old child underwent bilateral myringotomies and tube insertion with adenoidectomy. Preoperatively, she had an upper respiratory infection, but was eating normally. She was very active in the preoperative screening area. Immediately following the surgery, her oxygen saturations fell to the upper 80s while on blow-by humidified oxygen.

In preparation for an upcoming JCAHO inspection, the small community hospital (which had suffered from significant nursing shortages and thereby relied on many young and inexperienced staff members) was in the midst of a major internal educational campaign regarding HIPAA, encouraging all staff to be particularly attentive to issues of patient privacy. In keeping with this, the recovery room nurse (a recent graduate from nursing school) closed the "privacy" drapes, which left her unable to visualize the pulse oximeter.

Within the hour, the nurse heard loud inspiratory stridor coming from inside the curtain. The anesthesiologist and otolaryngologist were called stat, and

found the child in extremis. They managed the patient's airway over the next few minutes, barely avoiding intubation by "bagging" the patient.

The child was admitted overnight and was discharged the following morning after her respiratory status dramatically improved. She suffered no permanent adverse sequelae.

Missed TB

The Case

A 38-year-old white female with no past medical history presented to the hospital with fevers, respiratory failure, and bilateral pulmonary infiltrates. She was treated empirically with broad-spectrum antibiotics, which were continued even after her initial blood and sputum cultures returned negative. Fevers persisted and she soon developed acute respiratory distress syndrome (ARDS). The treating physicians considered bronchoscopy, but felt the patient was too ill to tolerate the procedure. An HIV test was sent and was negative. On hospital day 21, her providers considered the possibility of tuberculosis, and sent sputum for acid-fast bacilli (AFB) smear and culture. The AFB smears were negative. The patient continued to deteriorate, with progressive respiratory failure, and died shortly afterward. Several days later, the AFB cultures began growing *Mycobacterium tuberculosis*.

Fumbled Handoff

The Case

A 73-year-old female with history of hypertension, non-insulin dependent diabetes mellitus (NIDDM), and chronic renal insufficiency was admitted for an elective sigmoid resection and diverting colostomy. On postoperative day (POD) 2, the patient was tachycardic, despite receiving a low-dose beta-blocker. That same day, she informed her nurse that she had developed left leg pain. Assuming it was related to the epidural placed preoperatively, the nurse called anesthesia, and they responded by decreasing the epidural rate. The primary surgical team was not called at that time. On POD 3, the patient had no complaints for the primary team on morning rounds. Later in the evening, the cross-covering intern was called concerning the left leg pain. No information about this intern's findings was relayed to the primary team the next morning. On POD 4, the patient complained to the nurse of mild chest discomfort. She was seen by housestaff within 20 minutes and by the attending several hours later. Her exam was unremarkable. A workup was initiated, but within an hour of the attending's visit, the patient's blood pressure dropped to 70/40, followed shortly thereafter by a pulseless

electrical activity (PEA) arrest, from which she could not be resuscitated. Post-mortem examination revealed pulmonary embolism.

Autopsy Revelation

The Case

A 45-year-old male with development delay presented to the emergency department with acute abdominal pain. His mother, who was his main caregiver, accompanied him. The mother was talkative and answered all questions on his behalf, including questions about his symptoms and past medical history.

The mother described the current episode as the sudden onset of severe pain, which initially seemed to be in the epigastric area, but had since moved over to the right upper quadrant and flank. The patient nodded his assent throughout his mother's account. Mother and son stated that the pain was no longer as severe as it had been at its onset, roughly 2 hours earlier. She stressed that he had experienced very similar complaints the previous year, which were diagnosed as due to renal colic.

On physical examination, the patient was moderately obese and appeared in mild discomfort, but no acute distress. His vital signs were normal except for mild tachycardia to 100 beats per minute. Abdominal examination revealed mild tenderness with deep palpation in the epigastrium and right upper quadrant. There was no costovertebral angle tenderness, and rectal examination was unremarkable.

The emergency physician's working diagnosis was renal colic, but he also considered the possibility of gallstones. He planned to obtain a right upper quadrant ultrasound if the pain did not respond to treatment for renal colic or if laboratory tests suggested a hepatobiliary process.

The patient received an intramuscular injection of ketorolac (Toradol), which provided significant relief, as did a second injection 2 hours later. Serum chemistry and blood count results returned within normal limits. Urinalysis was not available, however, as the patient had forgotten the instructions and flushed his urine sample. He was discharged with a prescription for acetaminophen with codeine, instructions to drink at least 8 glasses of water a day, and a strainer for his urine in case he passed a stone, all of which the mother stated she was familiar with based on the previous episode.

The next morning, the patient's mother found him in bed completely unresponsive and with no palpable pulse. Ambulance personnel pronounced

him dead at the scene. The medical examiner requested an autopsy, which revealed a perforated gastric ulcer and widespread peritonitis.

Lethal Cap

The Case

A 9-month-old child was seen by her pediatrician for a fever and decreased appetite. She was found to have otitis media and was prescribed amoxicillin. The doctor gave the first dose to the infant in the office, demonstrating step-by-step how to deliver the medicine via syringe.

At home, the father drew up the next dose without removing the syringe cap. He gave the dose to the child who suddenly had difficulty breathing and collapsed. When emergency medical services (EMS) arrived, the child was intubated and transported to a children's hospital. Despite intubation, she could not be adequately ventilated. The tube was removed and intubation was tried again, still without improvement. The infant was then taken to the operating room to undergo bronchoscopy. The syringe cap was found lodged in her trachea. Evaluation in the subsequent days revealed brain death. The infant was removed from life support and died shortly thereafter.

OR Peeping

The Case

A healthy unmarried woman was undergoing a dilation and curettage (D&C) following an incomplete spontaneous abortion (miscarriage).

At this community hospital, a new operating room (OR) suite had recently opened. It was equipped with video cameras in all OR rooms to check staff location and activities, observe the status of ongoing procedures, and assist with development of educational materials. The video cameras are monitored at the nurses' station, located just inside the OR suite. As such, the monitors are visible to anyone who enters the OR doors, and sometimes to those standing outside the doors. Prior to surgery, the hospital admissions staff obtains general consent from patients for videotaping for "education and safety" purposes. The use, placement, and high visibility of the cameras in the OR is not explained in writing or discussed with the patient.

During the D&C procedure, the woman's face was shown on the OR video monitor. She was recognized by someone who passed the OR suite when the door was open. The serious privacy issues came to light after the passerby disclosed the woman's presence in the OR to other people. "Gossip" spread

around town about the woman's pregnancy and D&C. It raised a great deal of speculation and was embarrassing to the woman and others.

Crossing the Line

Case & Commentary: Part 1

A 46-year-old man was admitted with pneumonia and confusion. The patient underwent an extensive work-up including bronchoscopy, which revealed a pyogenic lung abscess, and an MRI of the brain, which showed multiple ring-enhancing lesions. Intravenous (IV) antibiotic therapy was initiated. Due to poor peripheral IV access, a central venous catheter (CVC) was inserted by the attending physician. The procedure was performed at the right internal jugular site. At the end of the procedure, the operating physician reported excessive bleeding from the catheter site, but this was eventually controlled by manual pressure over the site. A chest radiograph was obtained after the procedure, and a radiologist interpreted the film as showing the catheter lying in the distal right jugular vein.

Central venous catheterization can result in mechanical, infectious, and thrombotic complications.(1) Mechanical complications, such as bleeding, hematoma formation, pneumothorax, and arterial puncture and cannulation, typically occur at the time of insertion (Table 1). Bleeding complications occur more commonly in patients with coagulation abnormalities or elevated central venous pressure.

Central venous catheterization can be performed at the internal jugular, subclavian, or femoral venous sites. Femoral venous catheterization should be avoided except in emergencies because it is associated with an increased risk of infectious and thrombotic complications.(2-4) The subclavian vein is the preferred site, especially in patients with indistinct landmarks for internal jugular catheterization. The subclavian site has the lowest rates of infection, thrombosis, and arterial puncture.(2-6) There is no difference in the rates of pneumothorax for internal jugular versus subclavian vein placement.(6) However, it is more difficult to control excessive bleeding when it occurs at the subclavian site. Importantly, patients generally find subclavian catheters more comfortable than the internal jugular catheters.

The internal jugular vein usually runs just lateral to the carotid artery as it traverses the anterior triangle formed by the sternocleidomastoid muscles (Figure 1). However, this relationship is not present in 20% of individuals, in whom the internal jugular vein may lie medial, deep, or just superficial to the carotid artery.(7) In contrast to the variable anatomy of the internal jugular vein, the anatomy at the subclavian site is more constant. The subclavian vein begins at the lateral border of the first rib and joins the internal jugular vein

medial to the anterior scalene muscle to form the brachiocephalic vein (Figure 2). Throughout its course, it runs anterior and inferior to the artery. The junction of the middle and lateral thirds of the clavicle provides a useful surface landmark.

Several factors increase the risk of mechanical complications during CVC insertion. These can be divided into patient factors and operator factors. Patient factors include extremes of weight, prior surgery in the area of the site, prior catheterization at the same location, skeletal deformities (severe scoliosis, upper extremity or neck contractures), and inability to cooperate.(8) Perhaps the most important operator-related factor is experience. Physicians who have performed more than 50 catheterizations have half as many complications as less experienced operators.(3) Having three or more unsuccessful passes with the needle is also associated with increased complications.(8) Whenever possible, subsequent attempts should be made by a more experienced operator, or at a different site.

Post-procedure chest x-rays are used to confirm correct positioning of the catheter and to identify complications, such as hemothorax and pneumothorax. In general, radiographic confirmation of catheter location is reliable. When correctly positioned, the tip of the catheter lies at the cavo-atrial junction, at the level of the right mainstem bronchus (Figure 3). However, if a catheter is not inserted far enough, then the course of the venous and arterial system can be difficult to distinguish, which was probably the situation in this case (Figure 4). The suspected tip location suggests that at least 10 cm of the catheter was outside the patient's body, since most central venous catheters are 15-20 cm long. Conversely, if the catheter is inserted too far and enters the right atrium or right ventricle, arrhythmias or, less commonly, perforation of the myocardium can occur.

Case & Commentary: Part 2

Twelve hours after the procedure, the patient developed new dysarthria, dysphagia, and left hemiplegia. A repeat brain MRI showed new cerebral infarctions in the right frontal, parietal, and temporal lobes. A carotid ultrasound was obtained to rule out carotid stenosis. There was no evidence of carotid artery stenosis; however, the ultrasound showed that the CVC was within the lumen of the right carotid artery. The catheter was immediately removed. The patient suffered permanent neurologic deficits, including left hemiplegia. He was eventually discharged to a long-term skilled nursing facility.

Neurologic deficits following catheterization at the internal jugular site, similar to the ones seen in this case, suggest arterial injury or paradoxical embolization of thrombus or air through a right to left shunt. The timing of

this patient's neurologic deterioration favors an arterial injury. An air embolism would be expected to result in immediate symptoms during insertion (or withdrawal), and catheter-related thrombosis often develops after a period of time.

Arterial puncture occurs in approximately 5% to 10% of internal jugular catheterization attempts.(3,9) Although pulsatile bright red blood is typically encountered when arterial puncture occurs (hitting "Big Red"), this finding can be unreliable. For example, volume overloaded patients breathing 100% oxygen can have pulsatile venous blood that appears quite red, and patients who are hypotensive and/or hypoxemic may have minimally pulsatile arterial blood that is surprisingly dark.

The key to preventing serious injury to the artery is identifying the arterial puncture prior to dilating the vessel. The ideal technique should be quick, easy to perform, and inexpensive. The most definitive technique is to attach a pressure transducer to the needle and inspect the waveform. Alternatively, one can insert a single lumen catheter without dilating the vessel and attach the transducer to the catheter. Venous waves are easily distinguished from arterial waves. Another option is to construct a manometer with a 20-cm to 30-cm piece of sterile IV tubing flushed with saline. After vessel cannulation, the tubing is attached to the needle and held upright. Arterial puncture is easily identified, as the saline column will not drop and blood will pulsate through the top of the tubing. In contrast, venous cannulation results in an immediate drop in the column of saline. Sending a venous blood sample for gas analysis is another option. Although this method often works, the result may be difficult to interpret if the patient is particularly well oxygenated or if hypercarbia is present. Simultaneous analysis of radial artery blood improves the accuracy of this technique. The major drawback to blood gas analysis is time delay, which can be minimized when point-of-care testing is available. In the event that the carotid or subclavian artery is dilated, vascular surgical consultation may be indicated. This is particularly important if a large catheter, such as an introducer sheath or a dialysis catheter, has been placed in an artery.

Using real-time ultrasound to guide internal jugular vein cannulation reduces complications and increases success rates.(10,11) In one study, the success rate with ultrasound guidance was 100%, compared with 88% when ultrasound was not used. The same study showed that the incidence of carotid puncture was reduced from 8.3% to 1.7%, and the average access time was reduced by a factor of four.(12) By using this aid, the internal jugular vein is easily identified (Figure 5) even in patients with thick necks and poorly visible landmarks. In contrast, visualizing the subclavian vein with ultrasound is more difficult; it is probably for this reason that the use of ultrasound for subclavian placement does not clearly reduce the incidence of complications.(8) The lack of clear benefit at the subclavian site may also be

due to the more consistent anatomic relationship between the subclavian vein and surface landmarks.

Several inexpensive portable ultrasound machines are available for use (Figure 6). As with all new technologies, training is required to ensure optimal results. To avoid contamination of the site, specially designed sterile sleeves should be used to cover the transducer. Sterile gloves are not an appropriate alternative, because they do not cover the entire apparatus.

Mechanical, infectious and thrombotic complications of central venous catheterization are common but preventable. Reduction in mechanical complications can be achieved by ensuring adequate training and experience of the operator, preferential use of the subclavian site for vascular access, regular use of an ultrasound device to identify the target vessel when the internal jugular approach is necessary, and optimization of patient positioning prior to procedure. Table 2 lists several additional system-level interventions that may reduce the incidence of CVC-related complications.

To implement these changes with the greatest chances of success, health care systems should: (i) make it an institutional priority to reduce complications of central venous catheterization, (ii) identify a respected clinician to be an advocate for change, (iii) offer training courses in central line placement, (iv) ensure that necessary supplies (sterile drapes, portable ultrasound devices, chlorhexidine antiseptic solution, antibiotic-impregnated catheters) are readily available, (v) empower nurses to intervene when sterile precautions are not followed, and (vi) provide specific feedback to providers with high complication rates. Because brief, one-time interventions are not likely to result in lasting improvements, ongoing efforts to change both the attitudes and behaviors of providers are necessary.

Transfusion "Slip"

The Case

A married couple, Mr. and Mrs. M, was brought to the emergency department (ED) of a Level 1 trauma center after a half-ton truck that had skidded out of control struck their car. Mr. M appeared hemodynamically stable, but had bilateral femoral fractures. Mrs. M had been the driver. Her blood pressure remained low despite wide-open crystalloid infusions, and she had signs of peritoneal irritation on exam. Both patients were typed and crossed, although only Mrs. M appeared to need packed red blood cells urgently.

The husband and wife patients had been placed in a large trauma bay with two beds. In the commotion of stabilizing and assessing both patients, the blood typing tube for Mr. M was labeled with the sticker for Mrs. M. Once the

specimen was labeled and sent to the lab, this error would normally have been undetectable based on the standard protocols for handling transfusion products. By coincidence, however, Mrs. M had previously undergone a Cesarean section at the same hospital. She had been typed and crossed at that time. She and her husband did not share the same blood type (she was Type O and he Type A). The alert technologist in the blood bank noticed the change in blood type and inferred that a mistake must have been made. She called the ED immediately. They agreed to redraw her blood sample for re-typing, but also requested that O-negative blood be sent the ED immediately in case the patient deteriorated. Mrs. M thus never received the wrong blood.

This case represents a very serious near miss. But for the coincidence of Mrs. M's blood type being on file at the same hospital, she would have received a potentially fatal incompatible transfusion matched for her husband's blood type (A) and not her own (O).

X-ray Flip

The Case

A 19-year-old man presented to the emergency department with respiratory distress after blunt chest trauma. A digital chest radiograph was labeled backwards; a "left" marker was mistakenly placed over the right chest. There was a moderate pneumothorax seen on the film on the anatomic left side (the side of the aortic arch). On the radiograph, however, the pneumothorax appeared to be on the patient's right (Figure).

The resident assigned to the patient performed a brief physician examination, but based his localization of the pneumothorax largely on the reading of the chest radiograph. He thus placed a right chest tube. A correctly labeled follow-up chest x-ray showed persistent pneumothorax on the patient's left and the right-sided chest tube. A second chest tube was then placed, this time in the patient's left chest. The patient remained stable. The right chest tube was removed after the physicians confirmed that there was no air leak. There were no further sequelae.

Undiagnosed Vaginal Bleeding

The Case

The patient is a 34-year-old gravida 3, para 3 woman with a 2-year history of increasingly profuse vaginal bleeding. Over the past two years, the patient had been placed on oral contraceptives, but these had not stanched the bleeding. The patient reported having a Pap smear approximately 18 months earlier, read as "unsatisfactory, obscured by blood." However, she had not had a

follow-up study. A gynecologist had seen her about 6 months earlier, and told her she needed a hysteroscopy and a dilation and curettage (D&C). However, he explained that he did not accept Medicaid, which was her source of health insurance. Her follow-up remained sporadic, and her bleeding continued—profuse enough that she required hospitalization for transfusions twice in the preceding 2 months.

Her bleeding increased again, and she presented to the emergency department (ED). Physical exam revealed that the patient had an extremely friable exophytic cervical lesion, which was biopsied and confirmed to be invasive cervical cancer. Upon evaluation by a gynecologic-oncologist, she was found to be Stage IIB cancer. After undergoing radiation therapy and chemotherapy, she still has persistent disease. Her prognosis is currently guarded. Her oncologist believes that her delayed diagnosis profoundly affected her prognosis.

Environmental Safety in the OR

The Case

The infection control department of a hospital noticed a marked increase in the rates of post-operative sternal wound infections in surgical patients admitted to the hospital for coronary artery bypass graft (CABG) surgery. The increased infection rates were accompanied by increased readmissions and prolonged lengths of stay. Two patients had to have their sternum removed because of infection; two others died. One cardiac surgeon and his team were identified as having higher infection rates than others, even though they used the same operating room (OR) suites and facilities.

An infection control practitioner conducted "environmental rounds" within the OR suite to observe the surgical team during the entire CABG surgical procedure. She found that the team was very "sloppy"—members of the team wore loose hair and jewelry (earrings, necklaces); several also wore regular sandals into the OR. The infection control practitioner noted also that several team members did not re-scrub when moving from working on the saphenous graft in the patient's leg back to the patient's open chest.

Delay in Initiating Antibiotics Results in Fatal Error

Case & Commentary

A 21-year-old woman with a history of systemic lupus erythematosus (SLE), on long-term prednisone, presented to the emergency department (ED) with a few

hours of fever, chills, myalgias, and vomiting. On arrival to the ED, she was hypotensive, but responded to IV fluid resuscitation. Laboratory evaluation revealed an elevated white count. The medical housestaff evaluated her, contacted the admitting attending by phone, and admitted the patient to a medical ward with a presumptive diagnosis of viral syndrome versus food poisoning. She continued to require fluid resuscitation for blood pressure support. No antibiotics were given.

In the morning, 10 hours after admission, her condition began to deteriorate. She developed shock refractory to fluid resuscitation, and a subtle petechial rash (Figure) was noted. At that time, she was examined by the attending physician. Suspecting meningococcemia, the attending started antibiotic therapy and transferred the patient to the intensive care unit (ICU). Despite initiation of antibiotics and full supportive treatment, the patient had a cardiac arrest and died.

The error in this case reflects poor clinical judgment and a fund of knowledge deficit. The first premise in clinical care is to consider and treat the most life-threatening conditions, while waiting for patients' illnesses to declare themselves. Given her chronic prednisone use, this patient should have been recognized as an unstable, immunosuppressed patient. The differential diagnosis of hypotension in a patient on chronic prednisone must include early sepsis and adrenal insufficiency. Neither of these life-threatening conditions was apparently considered. Concerns about early sepsis should have resulted in the ordering of empiric broad-spectrum antibiotics and admission to an intermediate care unit. Consideration of adrenal insufficiency should have prompted the administration of intravenous hydrocortisone. In this instance, the hypotension was ascribed to volume depletion on the basis of a few hours of vomiting, an unlikely explanation. Additionally, the patient continued to require fluids for blood pressure support; the admitting team should have re-evaluated her for this ongoing hypotension. Continual patient re-evaluation is a critical skill, both to follow the progression of underlying illness and to ensure that the team is working with the correct diagnosis.

In this case, the attending physician was contacted by phone, although the nature of that contact is not specified. I refer to this type of supervision as "remote supervision." It applies anytime an attending is not physically present in a patient care unit to personally evaluate and manage patients. Remote supervision of residents is the most common mechanism of housestaff supervision, whether overnight or during the day. Oftentimes, faculty physicians are admitting patients (remotely) while simultaneously seeing outpatients. They make rounds late at night or early in the morning and thus rely on remote communication of clinical changes. Additionally, most institutions do not require overnight faculty presence. If institutions are going to care for patients this way, then standards must be set for quality of care. New admissions must be presented in their entirety to the attending. If the

attending has any concerns regarding the clinical skills or decision making of the team, then he or she must evaluate the patient personally. This standard should be applied regardless of time of day.

Changes in inpatient medicine over the past 10 years challenge the concept of remote supervision. Given the managed care revolution, the need to manage patients effectively has become a fiscal imperative. Cost containment and demands for improved quality of care have led to the birth of a new specialist in medicine: the hospitalist. Defined as individuals who practice at least 25% time in the inpatient setting (1), hospitalists hold the advantage of having the inpatient ward as their practice venue. They are present in the hospital more often (around the clock in some institutions), enabling the timely evaluation of patients. Supervision is no longer remote. Although there are no data to confirm that fewer errors occur on hospitalist services, two studies at teaching hospitals showed that hospitalists led to reduced lengths of stay, cost of care, and mortality.(2,3) In an analogous way, the on-site presence of intensivists (who are, in essence, "ICU hospitalists") appears to improve outcomes (4), and has been promoted by the Leapfrog group as one of its quality standards.(5)

Although the data are limited, it makes intuitive sense that the more timely involvement of attending physicians such as hospitalists and intensivists would lead to less expensive and better quality care. Nevertheless, a recent study on the presence of in-house attending trauma surgeons showed no impact on mortality or length of stay.(6) Studying the impact of different organizational models of care is notoriously difficult, and institutions will need to decide on staffing and supervision models based on imperfect data.

The rapid growth of the hospitalist model—both within and outside academic hospitals—seems to indicate that leaders are convinced of its benefits.(7) The introduction of hospitalists into academic medical centers is likely influencing graduate medical education.(8) One great challenge is to balance resident autonomy with the appropriate level of supervision when hospitalists are integrated into training programs. At least one study supports that their presence does not compromise resident autonomy.(9)

The duty-hour regulations imposed by the ACGME in July 2003 are also likely to impact and change the level of attending involvement. These regulations require that, when averaged over 4 weeks, housestaff work no more than 80 hours per week and have 1 day in 7 off. They also require that every duty period be separated by 10 hours and that no shift exceed 24 continuous hours with an additional 6 hours for education and transfer of care.(10) To meet these requirements, many programs have implemented or expanded night-float programs.(11,12) The number of handoffs between providers has certainly increased. This discontinuity of care by housestaff places more reliance on the attending physicians for the details of patient care. It is likely that duty-hour

reform will improve resident fatigue; however, it may compromise patient safety. New systems will need to be adopted to improve continuity. One such mechanism would be to have continuous presence of hospitalists throughout the day and night.

At least one study demonstrates that medical errors among internal medicine residents are not uncommon. One hundred fourteen internal medicine residents completed an anonymous questionnaire describing their most significant mistake and their response to it.(13) Mistakes included errors in diagnosis (33%), prescribing (29%), evaluation (21%), communication (5%), and procedural complications (11%). Serious adverse outcomes occurred in 90% of the cases, including death in 31% of cases. Most importantly in this study, only 54% of house officers discussed the mistake with their attending physicians, and only 24% told the patients or families. Those who accepted responsibility for the mistake and discussed it were more likely to report constructive changes in practice.(13)

Given that errors are not uncommon among residents and accountability is less than adequate, program directors and those responsible for medical education play a critical role in patient safety. The overall role of the program director is to help residents turn into independent practicing physicians. Errors related to fund of knowledge deficits, inadequate clinical skills, poor clinical judgment, and problem solving must be addressed from the perspective of the individual, the program, and the health care system. Errors never occur in a vacuum: usually, system-based issues are contributing factors.

Program directors have three roles when it comes to dealing with medical errors. The first relates to the providers: the responsible faculty must discuss the error with the house officers involved. Oftentimes, the program director can facilitate this. Many housestaff worry when their program director is notified of their mistakes, concerned that such information will harm their fellowship or job prospects, or that they'll be sued or suffer personal embarrassment. Regardless, the program director is the only individual who can determine whether an error is an isolated circumstance or represents a problematic pattern of performance. If such a pattern is present, then it needs to be carefully examined. The pattern may reflect basic fund of knowledge and clinical skills deficits that are easily remediable. It may also reflect underlying depression, attention deficit disorder, substance abuse, etc. All of these issues must be addressed for residents to successfully negotiate training.

The second role of the program director is in defining the educational curriculum. If the error is felt to be common within the program, then the program director should develop an educational initiative designed to prevent similar occurrences, such as a resident report, clinicopathological conference

(CPC), or Morbidity and Mortality (M&M) conference devoted to discussing the case. The third role of the program director is to serve as a liaison between the program and the health care system. If significant systems issues are identified, then that information needs to be communicated to the appropriate individuals in the hospital administration. Too often, there is a disconnect between residency issues and the institutional quality apparatus. Residents, by operating at the sharp end of care, are often the ones best positioned to identify major systems flaws that require action.

The barriers mentioned above are very real and impact our ability to learn from our mistakes. At our institution, we have adopted several venues for error reporting that have helped the program directors carry out all three roles. We now have monthly patient safety discussions at residents' report. In these sessions, we discuss cases where errors or potential errors were thought to occur due to systems-related issues in the process of care. Importantly, the vice president for hospital quality and patient safety moderates these sessions. The format has enabled the identification of many systems issues that have subsequently been improved. While initially skeptical, the housestaff have embraced this format as a constructive way to have a voice in the larger process of care.

In addition to reporting within these and other conferences (eg, M&M conferences), we have also implemented an anonymous web-based reporting system called Penn Occurrences Reporting and Tracking System (PORTS). This system allows any provider to submit an online report of any situation that created a near miss for an adverse event or actually caused an adverse event. This information is collected and collated centrally by the institution-based Clinical Effectiveness and Quality Committee. Their role is to identify not only individual events but also look for patterns of events that can lead to systems-based improvements. Residents in our program have embraced this anonymous reporting tool as a way to improve the system of care at our hospital.

If error reporting is done in a non-biased, non-confrontational format with an opportunity for learning, it can lead to substantial improvements in both education and patient care. As physicians, we have a responsibility to ourselves and our patients to develop systems to minimize errors. As educators, we have an obligation to help trainees understand the importance of their roles as both providers of care for individual patients and as leaders in improving the systems of care in which they work. Recognizing the complex factors that contribute to these errors is necessary to prevent future occurrences.

Crushing Chest Pain: A Missed Opportunity

Case & Commentary: Part 1

A 62-year-old female presented with 12 hours of crushing chest pain. Her physical exam revealed a blood pressure of 140/90, a heart rate of 110, and a respiratory rate of 16. An electrocardiogram revealed left ventricular hypertrophy with strain. Review of the chest x-ray in the emergency department (ED) revealed no abnormalities. The patient was treated for an acute coronary syndrome (ACS) with heparin, aspirin, morphine, and a nitroglycerin drip. Cardiac enzymes were drawn. She was admitted to the cardiac care unit (CCU).

Seven hours after admission, the patient became hypotensive, with a systolic blood pressure in the 80s and a heart rate in the 120s. A repeat electrocardiogram revealed no significant changes. Right-sided leads showed no evidence of right ventricular infarct. The first set of cardiac enzymes was equivocal, and a CPK-MB was minimally elevated.

Chest pain is a common complaint in the ED, increasingly so as patients heed advice to find the closest hospital for evaluation. Correct diagnosis is critical in this setting: the patient's survival may hinge on making a timely and accurate diagnosis.

In a 62-year-old female with crushing chest pain, most physicians would choose an acute coronary syndrome as the most likely diagnosis, as in this case. They would arrive at this diagnosis knowing that coronary artery disease is common in the aging population and that unrelieved "crushing" pain often indicates myocardial ischemia. In the lingo of medical decision-making, this diagnosis emerged subconsciously from the 'availability' or the 'representativeness' heuristics.(1) Availability implies that the diagnosis springs to mind, likely because ED physicians often see patients whose chest pain is due to ACS. Representativeness implies a mental match between the patient's symptoms and the characteristic symptoms of ACS stored in the clinician's memory. In the absence of expert skills, heuristics are remarkably effective in helping us reach a correct diagnosis rapidly, accurately, and with little conscious effort. Unfortunately, they also lead to occasional diagnostic errors, for example, when the correct diagnosis is not considered.

Ideally, the ED clinicians would have used a Bayesian approach, such as 'expected value' decision-making, to derive the most probable diagnosis.(2) A Bayesian approach cannot guarantee success, but in theory has the highest likelihood of selecting the correct diagnosis. This approach begins by listing all the diagnostic possibilities and the likelihood of each. In one study, the most common cause of chest or back pain was acute coronary syndrome, present in 24.4% (Table 1).(3) The second step in the Bayesian approach is to adjust the initial probabilities using Bayesian calculations to incorporate any

information uncovered in data gathering.(2) This patient described her chest pain as "crushing." Although this description has long been considered a hallmark of myocardial infarction (MI), studies suggest it is a weak predictor, with a positive likelihood ratio less than 2.(4) In addition, this patient lacked physical findings that increase the likelihood of MI (diaphoresis, a 3rd heart sound, hypotension, or rales). Finally, her ECG had no features suggestive of MI, a feature that modifies the possibility of ACS by a likelihood ratio of 0.1 to 0.3. Combining these likelihood ratios with the pre-test probability of 24.4% yields an overall likelihood of cardiac ischemia of less than 17%. These calculations can be performed simply by using the 'odds' form of Bayes theorem (Table 2) or a simple nomogram.

An alternative approach is to use an algorithm that simulates expert thinking. Many such aides are available, and these improve the sensitivity and specificity of diagnosing cardiac ischemia compared with 'clinical judgment.'(4-8) For example, one study used a formula based on seven clinical variables to predict cardiac ischemia,(8) and another derived a prediction rule using four clinical variables: past history of MI, presence of diaphoresis with chest pain, ST elevation, and the presence of a Q wave.(5) By these formulae, this patient's likelihood of having a myocardial infarction is less than 7%, or less than 2%, respectively.

The ED team correctly decided that the patient would benefit from observation in the CCU. Their initial diagnosis of ACS was reasonable in view of the history, and the fact that this diagnosis, in terms of base rates (Table 1), is orders of magnitude more likely than alternatives, such as acute aortic dissection (AD) (80 times less likely) or pulmonary embolism (60 times less likely). However, had the team incorporated all available data, they might have realized that the likelihood of cardiac ischemia was substantially less than initially assumed. This might have prompted a search for an alternative diagnosis.

Case & Commentary: Part 2

The team re-reviewed the chest x-ray and discovered an abnormality in the aorta: a 1-cm separation between the intimal calcification and the adventitial outline of the descending aorta (Figure 1).

The mortality rate of undetected AD approaches 1% per hour, and the diagnosis is missed in 25%-50% of patients.(9,10) Death from a missed AD is preventable, because AD can be easily and definitively identified by appropriate imaging (CT scan, MRI, or trans-esophageal echography), and survival exceeds 90% with prompt diagnosis and management.(11) However, the challenge is to consider the diagnosis in the first place.

The classical presentation is chest or back pain of acute onset, severe from the outset, tearing or ripping in quality.(10,12) Unfortunately, atypical presentations are common, because symptoms will vary depending on the exact anatomic location of the dissection and the secondary vasculature involved. Pain may not be present at all; in one series, 15% of patients with AD reported no pain.(9) Physical findings that may support the presence of a dissection include pulse deficits (greater than 20 mm differential), new aortic regurgitation, signs of pericardial tamponade, and focal neurological deficits (Table 3). The majority of patients, however, will have no specific physical findings.

In 90% of patients with AD, the admission chest x-ray is abnormal.(10) Abnormal aortic contour (sensitivity = 71%) and a widened mediastinum (sensitivity = 64%) are the most common findings. As in this case, the x-ray may show the 'calcium sign'—a separation by greater than 1 cm between the intimal calcification and the outer adventitial border. Problems degrading the test characteristics of the chest x-ray in this setting include vagaries in the test itself and problems with interpretation. For example, the apparent width of the mediastinum can be increased by a poor inspiration or supine positioning of the patient. Substantial inter-observer variability is encountered in the reading of chest x-rays.(13) In summary, a normal chest x-ray should not be used to exclude the possibility of AD.

A reliable blood test would be ideal to simplify the diagnosis of AD. Currently the use of D-dimer is being evaluated for this purpose. A recent report found a 100% sensitivity for D-dimer in detecting AD in a small series of patients.(15) Although this test lacks specificity (it may also be elevated in pulmonary embolism, cancer, DIC, sepsis, etc.), a negative result may help physicians reliably rule out AD. The specificity problem may be solved by measuring myosin heavy chain, released from vascular smooth muscle.(16) However, the utility of either test in the evaluation of AD has yet to be validated.

Case & Commentary: Part 3

A transesophageal echocardiogram revealed an ascending aortic dissection (Figure 2). Anticoagulation therapy was discontinued, beta-blocker therapy was initiated, and cardiothoracic surgery was called. The patient was transported to the operating room. Upon arrival in the operating room, the patient became progressively hypotensive, coded, and died. Post-mortem autopsy revealed hemorrhage into the pericardium.

What led to the fatal diagnostic error in this case? Delays in diagnosis of AD have been associated with incomplete historical questioning and atypical presentations.(14) This patient's death is the result of errors in each of the

cardinal dimensions of clinical decision-making: data gathering, hypothesis generation (synthesis), and verification.

Data Gathering: The most critical error in this case was interpreting the chest x-ray as normal. This is a cognitive error, which may be knowledge-based (if staff were never trained to recognize abnormalities of the aorta) or skill-based (if staff were knowledgeable of the x-ray changes of AD but did not appreciate these on the films). In addition, the misread chest x-ray reflects a widespread "systems" flaw, where ED staff read chest x-rays instead of expert radiologists. This practice contributes to an untold number of diagnostic errors in medicine and illustrates the challenge medicine will face in reducing diagnostic error in the future. The error can be prevented, but at the substantial cost of having expertise available when needed. Teleradiology may be a solution for some institutions, but credentialing radiologists in another city, state, or country, has yet to be standardized.(17)

Additional errors in data gathering may have contributed if the history was incomplete. Rosman and colleagues found that clinicians correctly identified AD in more than 90% of patients if the history included three essential questions regarding the chest pain: the quality of the chest pain, its severity, and its location.(18) In contrast, the diagnosis was correct in less than half if all three questions were not asked.

Synthesis: The ED physicians assigned a diagnosis of ACS in this patient, without seriously excluding other possibilities. If the initial presentation does not "trigger" the correct diagnosis, it is unlikely to ever be considered.(19,20) The Bayesian approach would guarantee that the diagnosis of AD would have been considered.

Verification: Once a diagnosis is reached, clinicians have a tendency to stop thinking. An existing diagnosis has almost infinite inertia. This phenomenon of "premature closure" is possibly the most common cognitive error in internal medicine.(21) The CCU team in this case made another cognitive error when they accepted the ED diagnosis without re-examining the facts and independently re-thinking the case. Related cognitive biases include "framing" (we are overly biased by the way in which a case is presented; we tend to blindly accept a previous diagnosis established by others, or even ourselves), and "anchoring" (fixating inappropriately on an early diagnosis). To their credit, the CCU team eventually did re-think the case when the patient's condition changed. If a patient's course takes an unexpected turn, it is important to re-think initial assumptions and consider recruiting a colleague or consultant to evaluate the case anew.

Cognitive errors are all too common in medical decision-making. Although they can never be eliminated, they can be reduced by learning optimal decision-making strategies, understanding the intrinsic biases of using

heuristics, and improving metacognition (the ability to monitor the accuracy of our own thought processes).(22-24) For example, the tendency to premature closure can be offset by conscious efforts to keep an open mind. Clinicians should routinely generate a complete differential diagnosis in every case. Consider applying the "crystal ball experience"—after reaching a diagnosis, pretend you can look into the future with your crystal ball and see that your initial diagnosis is wrong. What alternatives should be considered?

Triage Time Bomb

The Case

A parent presented with a child to the emergency department (ED) triage area (located around the corner and down the hall from the actual ED). The child was febrile, and had been vomiting and having diarrhea. After evaluating the child, who was still vomiting and had several episodes of diarrhea in the triage cubicle, the triage nurse was unsure about how to administer acetaminophen to the child. The nurse walked back to the ED to ask the physician about this. The doctor advised the nurse to bring the child to an ED exam room immediately (rather than wait for her "turn"), so that the child could be evaluated and receive intravenous (IV) fluid and possibly antiemetics. The physician explained to the nurse that the child might be dehydrated, and that acetaminophen could be given once these symptoms were controlled.

After receiving these instructions from the doctor, the nurse alerted the ED charge nurse of the plan. This nurse told the triage nurse not to bring the child back to the ED yet, because not enough staff members were available to care for the child. She stated that some patients were being discharged, and when they were, then the child could be brought back. The triage nurse walked back out of the ED and down the hallway and relayed this altered plan to the child’s parent, who then decided to take the child elsewhere for treatment.

Later in the evening, it was discovered that the child had been taken to another local hospital ED in full arrest.

Ruptured Heterotopic Pregnancy

The Case

A 43-year-old woman, gravida 3 para 2, presented at 16 weeks' gestational age with abdominal pain. Her current pregnancy was the result of in vitro fertilization (IVF) with a donor egg. An outpatient ultrasound at 14 weeks was reportedly normal. On the day of presentation, she had experienced a sudden onset of severe lower abdominal pain followed by nausea and vomiting.

Responding paramedics documented transient loss of consciousness and difficulty recording blood pressures en route to the emergency department (ED). In the ED, she was hypotensive and tachycardic with an initial spun hematocrit of 28. The ED physician performed an ultrasound, which showed an intrauterine pregnancy and free fluid in the peritoneal cavity. The ED physicians were concerned about a ruptured appendix.

After surgery and obstetrics were informed of the patient, she was given IV fluids and sent to the CT scanner. The patient was seen in the CT scanner by the obstetrics resident, who after reviewing the history and noting the patient's appearance (hypothermic, tachycardic, and hypotensive), felt the patient was at high risk for a ruptured heterotopic pregnancy (a pregnancy in which one embryo implants inside the uterus and another is outside the uterus [Figure]). The patient was pulled out of the scanner and taken emergently to the operating room, where an exploratory laparotomy found a 12-week fetus in the right fallopian tube along with 4 liters of peritoneal blood.

To Resuscitate or Not?

The Case

A critically ill end-stage AIDS patient was hospitalized for end-of-life care. Given the state of his disease, his code status was Do Not Resuscitate/Do Not Intubate (DNR/DNI), though he was still receiving active care. The patient was suffering from multiple concurrent infections requiring intravenous antibiotics.

The patient in the room next to him was also receiving antibiotics. Inadvertently, the antibiotics were switched at the nursing station, resulting in the administration of Nafcillin (a penicillin-like antibiotic) to the AIDS patient, who in the past had a known anaphylactic-shock reaction to penicillins. The difficulty was, if the AIDS patient developed anaphylaxis to the Nafcillin, there was a good chance he would suffer a cardiopulmonary arrest, given the advanced state of his illness. If this were to occur, he would likely die if heroic measures were not taken.

The nurse taking care of both patients realized the error after she went to give the other patient his antibiotics and saw that the printed label did not match the patient's name. Unfortunately, the wrong medication had already been given to the AIDS patient. After noticing the error, the nurse called the covering physician. The physician spoke to the patient, advised him that he might possibly suffer anaphylaxis to the errant medication, and asked him if he wanted to maintain his code status as DNR/DNI.

The patient was treated prophylactically for the possibility of allergic/anaphylactic reaction. For the next several hours, his nursing care became more intensive with more frequent vital sign checks. Luckily, he did not suffer any adverse outcome from the medication. By the next morning, it was clear that there were no sequelae.

Inadvertent Castration

The Case

An 83-year-old man presented with a left groin mass, "which had been there for years" but had recently increased in size. The patient described persistent aching in his left scrotal area, with no identifiable exacerbating or alleviating factors. He noted no change in bowel or bladder habits and reported taking a stool softener. No history was elicited or offered regarding prior genital surgery. Physical examination showed a 20-centimeter left groin mass with some superficial skin ulcerations. The mass was non-tender and was not reducible. The right groin and scrotum were unremarkable.

The patient underwent surgery with a preoperative diagnosis of direct left inguinal hernia versus left hydrocele. Although preoperative ultrasound might have allowed this differentiation, it was not performed. Exploration of the left groin revealed a relatively small direct hernia and large left-sided hydrocele (Figure). The planned repair of the direct hernia was carried out, but an intra-operative decision was made to perform complete excision of the hydrocele, spermatic cord, and testicle on the left. The operation was completed without complication.

In the recovery room, the surgeon discussed the changes to the planned procedure with the patient's wife, who informed the surgeon that the patient's right testicle had been removed after a traumatic injury many years earlier. In subsequent discussions with both the patient and his wife about hormonal replacement, the patient revealed that he had not been sexually active for several years. The patient was informed of the benefits of hormonal replacement—on energy level, muscle mass, and bone density—regardless of sexual activity. He elected to receive periodic, intramuscularly injected testosterone

Don't Push

The Case

A 37-year-old HIV-positive woman was brought to the emergency room by her family because she had exhibited altered mentation for 3 days. The patient had been diagnosed with HIV infection 3 years earlier. Her opportunistic

infections included thrush and *Pneumocystis carinii* pneumonia (PCP). She had never received highly active antiretroviral therapy (HAART). Nevertheless, her lowest CD4 count was 560 and her viral load was low. The patient did not have any significant past surgical or psychiatric history. Medications on admission included only trimethoprim/sulfamethoxazole [Bactrim] for PCP prophylaxis.

The patient's mental status deteriorated rapidly after admission: she tossed about on her bed and had visual and auditory hallucinations. Per the hospital's safety protocol, the planned lumbar puncture was put on hold because of her agitation. Neurology and psychiatry consultations were sought. The psychiatry team recommended haloperidol administered via intravenous (IV) push 5 mg every 20 minutes until sedation was achieved, so that the neurologist and psychiatrist could evaluate the patient. However, after 3 doses of haloperidol, the patient's face turned pale and she started gasping for air. The patient was connected to a cardiac monitor on a crash cart, which showed polymorphic ventricular tachycardia ("torsade de pointes") (Figure).

The patient received IV magnesium sulfate immediately. In the cardiac intensive care unit, she required placement of a transvenous pacemaker. She was able to return to a regular medical floor 1 day later, and her mental status improved without any intervention over the subsequent week.

Misread Label

The Case

An infant was born with sluggish respirations. During labor the infant's mother had received meperidine [Demerol, a pain medication], a narcotic with a half-life of 2.5-4.0 hours in adults and 12-39 hours in neonates. The physician started resuscitation and ordered naloxone [an opiate antagonist]. Shortly after administration of the medication, the infant's condition began to deteriorate further.

Prompted by the proximity of the deterioration to the administration of the naloxone the physician checked the packaging of the drug. The syringe had inadvertently been filled with Lanoxin [digoxin, a cardiac medication] instead of naloxone. The packages of both drugs, made by the same manufacturer, were almost identical. ECG revealed bi-directional ventricular tachycardia, consistent with digoxin toxicity.

Approximately 1 hour later the infant died. A post-mortem digoxin level was 17 ng/ml (therapeutic range 0.8 to 2 ng/ml).

Waiting Too Long

The Case

A 31-year-old gravida 1, para 1 woman presented at 40 weeks in the early stages of labor having received limited prenatal care at an outside clinic. Physical exam performed by the obstetrics resident was suggestive of placenta previa and an anesthesiologist was called to prepare for a cesarean section (C-section). The anesthesiologists were short-staffed and also covering the operating rooms on a different floor, but felt they could be available if needed emergently. Shortly afterward, fetal heart rate monitoring suggested fetal distress and the patient was transferred to the operating room for emergent C-section. The anesthesiologists were called again but were unavailable due to another operative emergency. After significant delay, the patient was ultimately anesthetized and underwent C-section. Unfortunately, the baby was delivered with profound neurologic abnormalities, including quadriplegia and cortical blindness.

The Missing Suction Tip

Case & Commentary: Part 1

A 65-year-old, 124-kg man with aortic stenosis and coronary artery disease underwent a combined aortic valve repair and coronary artery bypass grafting. The patient's surgery, scheduled as the second case of the day, began in mid-afternoon. The surgery was complicated by a prolonged time on bypass, totaling 7 hours after incision. During the post-bypass period, the scrub nurse noticed that the removable, small (1 cm), round metal tip of the surgical suction catheter was missing. He notified the surgeon. The surgeon replied, "You'll find it on your table somewhere," and continued to attain hemostasis and close.

The nurse searched frantically without success. He recalled that the tip had been causing problems by clotting earlier in the case, preventing adequate suction. He surmised that it must have been removed at that time. He theorized that the tip had found its way into a basin of saline that was then, much later, inadvertently used to irrigate the open wound. The nurse notified the surgeon that he believed the suction tip catheter was inside the patient.

Missing suction tips and other items left in body cavities during surgery are often called "retained foreign bodies." Case descriptions of retained foreign bodies appear with regularity in the popular press (1), and may result in substantial complications and death.(2) Unfortunately, their true incidence is unknown. Risk factors include emergency surgery, an unexpected change in a surgical procedure, and higher body mass index.(3) Because retained foreign

bodies may cause death, bowel perforation, sepsis, repeat surgery, and malpractice litigation, there are recommended practices for counting sponges and instruments.(4) However, 88% of retained foreign bodies occurred in the setting of a final count that was mistakenly thought correct.(4)

Case & Commentary: Part 2

In preparing to close, the surgeon quickly searched the chest cavity but did not find the suction tip. The anesthesiologist suggested an x-ray be obtained before closing the chest. However, the surgeon felt that the risk of the tip being in the chest was low and decided to defer the x-ray until after the chest was closed.

If a retained foreign body is suspected, surgical teams should consider rechecking sponge and instrument counts, manually searching the surgical site, and ordering an intraoperative radiograph.(5) Some authors suggest routine intraoperative radiographs after all high-risk procedures, regardless of the surgical team's suspicion of a retained foreign body. Because neither routine sponge counts nor intraoperative radiographs have been tested in prospective studies (6), the standard of care remains unclear.

Case & Commentary: Part 3

A post-operative x-ray confirmed the tip was somewhere inside the patient's chest. The patient was taken back to the operating room for removal of the tip. The re-exploration required that the patient go back on cardiopulmonary bypass, receive several additional units of blood products, and remain in the operating room for at least 6 additional hours. Luckily, however, there were no long-term adverse sequelae.

What went wrong in this case? The patient's weight is a risk factor clearly identified in the medical literature.(3) Other possible risk factors (although not conclusively identified by research) include the complexity and duration of the case, along with provider fatigue (since it was an afternoon case). An intraoperative x-ray likely would have detected the suction tip. Perhaps the surgeon believed it was more important to end the operation than to wait for an intraoperative radiograph. At times, this line of reasoning may be correct—in many institutions, the wait can be long enough to have negative clinical implications for the patient. If so, this error may actually have resulted from actions taken by a single individual (the surgeon) to compensate for other problems in the broader work environment.

Another interesting contributing factor featured prominently in this case is the communication among the team members. Research in aviation and other industries has illuminated the importance of communication and teamwork

for preventing and managing errors in demanding environments. The aviation experience has also highlighted the contributing factors that lead to teamwork and communication breakdowns. Analysis of this case in light of this experience provides additional insight into what went wrong.

The information provided does not allow definitive interpretation of the communication between the nurse, the surgeon, and the anesthesiologist. Perhaps the surgeon doubted the nurse's suggestion that the tip was in the chest cavity, and thus at the end of the case did not follow the anesthesiologist's advice to obtain an intraoperative radiograph. It is possible that the surgeon was not listening to the advice of other team members, or, although he heard the advice, he was perturbed that his judgment was questioned. One study that used a survey adapted from the aviation industry supports such an interpretation: 40% of surgeons surveyed believed that junior team members should not question decisions made by senior team members.(7) A broader and related issue reflected in this survey was that almost 40% of surgical nurses rated the quality of teamwork and collaboration with surgeons as low.

Alternatively, the nurse may have communicated poorly. Did he clearly and directly say, "I am very concerned that we left the catheter tip in the chest cavity—we should look for it"? Or did he raise ambiguous questions like, "Has anyone seen the catheter tip?"; "I wonder where the tip is"; or "I hope we have everything"? Such indirect comments may not have raised suspicion even in a surgeon open to questioning by other team members.

The observable communications and actions of this team can be a focus of improvement efforts, but they should also be viewed as symptoms of problems in the broader operating environment. This lesson has been learned from years of research on human performance in aviation and other industries.(8) When investigating and analyzing this event, the goal should be not only to identify the communication problems but also to understand *why* the surgical team's communications and actions made sense at the time.

What lies behind communication breakdowns like this one? Based upon research and accident investigations in aviation and other industries, at least four broad system failures can lead to communication breakdowns:(9)

- differences between team members' goals;
- differences between team members' interpretation of events (nurses and physicians interpret situations differently);
- knowledge that did not make it into the team consciousness (due to fear of speaking up or if one person assumes that others have the same knowledge they have); and

- other features of the operating environment (noise, lighting, new equipment, or technology).

Root cause analyses are often used to identify such "system errors" in hospitals. Other complementary methods elicit participants' understanding of an event and also help identify factors in the broader environment that influenced their thinking and behavior.(10)

Once these system errors are identified and corrected, it still may be necessary to focus on teamwork and communications. This is an interest of many patient safety researchers due in part to the success of aviation's Crew Resource Management (CRM) programs (11) and other efforts to understand and improve teamwork.(12) Efforts are currently underway to identify the team-related behaviors that are important in health care. Researchers have identified behaviors relevant to this case—for example, information sharing, inquiry, and assertion—that may help reduce and manage medical errors such as retained foreign bodies.(13,14,15)

Unfortunately, only one study has examined the effectiveness of CRM-like programs in real work environments (as opposed to simulators).(16) Therefore, it is premature to recommend comprehensive CRM training programs for health care providers. Other focused efforts to improve teamwork are showing promise. These include the use of daily goals (all providers on the team agree upon the goals for the patient each day) (17) and collaborative rounds.(18)

Cases of retained foreign bodies should be thoroughly analyzed to identify communication breakdowns in the operating room, as well as the broader operating room environment and system factors that led to the event.

40 of K

The Case

An 81-year-old female maintained on warfarin for a history of chronic atrial fibrillation and mitral valve replacement developed asymptomatic runs of ventricular tachycardia while hospitalized. The unit nurse contacted the physician, who was engaged in a sterile procedure in the cardiac catheterization laboratory (cath lab) and gave a verbal order, which was relayed to the unit nurse via the procedure area nurse. Someone in the verbal order process said "40 of K." The unit nurse (whose past clinical experience was in neonatal intensive care) wrote the order as "Give 40 mg Vit K IV now."

The hospital pharmacist contacted the physician concerning the high dose and the route and discovered that the intended order was "40 mEq of KCl po." The pharmacist wrote the clarification order. However, the unit nurse had already

obtained vitamin K on override from the Pyxis MedStation® (an automated medication dispensing system) and administered the dose intravenously (IV). The nurse attempted to contact the physician but was told he was busy with procedures. A routine order to increase warfarin from 2.5 mg to 5 mg (based on an earlier INR) was written later in the day and interpreted by the evening shift nurse as the physician's response to the medication event. The physician was not actually informed that the vitamin K had been administered until the next day. Heparin was initiated and warfarin was re-titrated to a therapeutic level. The patient's INR was subtherapeutic for 3 days, but no untoward clinical consequences occurred.

Urine a Tough Position

The Case

A 22-year-old unmarried woman came to her doctor's office worried that she might be pregnant. Although she did not want to have a baby at that time, she stated that she would carry the pregnancy to term if she were pregnant.

The patient collected her own urine sample and placed it in the specimen cabinet, which opens into the laboratory. A urine specimen already placed in the cabinet by a different patient had not yet been labeled and processed by the lab technician. Five minutes later, the physician was informed that the pregnancy test was negative. The physician conveyed this result to the patient, much to her great relief.

After the physician left the room, he was informed that the two specimens had likely been switched. The other urine sample belonged to a diabetic patient; the technologist suspected a mix-up after a urine dipstick on that sample indicated elevated glucose. Both patients were asked to resubmit urine samples; in fact, the patient was pregnant.

The physician was placed in the awkward position of informing the patient that the samples had been switched, and appropriate sympathetic counseling was made more difficult.

To LP or Not LP

The Case

A 4-month-old male infant was seen in the office setting of a large multisite practice. He presented with fever and irritability without an obvious source. He was referred to the local pediatric emergency department for further

evaluation. Parents were advised the reason for the referral was so that he could get a "blood test" performed.

Because the clinic was busy, the provider was unable to call the emergency department (ED) physician in a timely manner. The parents presented to the ED and said they were there for a "blood test" and were referred to a local lab for further evaluation. At the lab, they were informed that the doctor had not called in any lab test orders. The lab asked the patient´s family to wait while the physician was called, but while waiting the infant became more obtunded and toxic. At that point, the parents decided to leave and go to another hospital ED for evaluation. Meanwhile, the original physician called the first ED for the lumbar puncture (LP) results. He was informed that the patient had been sent to the lab and was not seen in the ED. At the second ED, an LP was done after another physician evaluation, and the child was diagnosed with meningitis. Despite the several-hour delay, the child was treated with 10 days of medication and recovered fully.

The Other Side

Case & Commentary: Part 1

A 33-year-old woman with microinvasive vulvar carcinoma was admitted to a teaching hospital for a unilateral hemivulvectomy. After the patient was intubated for general anesthesia, the trainee reviewed her chart and noted that the positive biopsy was from the left side. As the trainee prepared to make an incision on the left side of the vulva, the attending surgeon stopped him and redirected him to the right side. The trainee informed the attending that he had just reviewed the chart and learned that the positive biopsy had come from the left side. The attending physician informed the trainee that he himself had performed the biopsies and recalled that they were taken from the right side. The trainee complied and performed a right hemivulvectomy.

The next day, the Chief of Pathology called the trainee to inquire about the case. The specimen he received was labeled "right hemivulvectomy" and did not reveal any evidence of cancer; whereas, the pre-operative biopsies that he had reviewed (labeled "left vulvar biopsy") had been positive. He wondered if there had been a labeling error.

Wrong site surgery is a potentially devastating event for all concerned. The full extent of this problem is unknown. Although rare in relation to the enormous number of operations performed, it is nevertheless a significant patient safety issue. From January 1995 to March 2001, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) identified 114 wrong site surgery reports from 1152 sentinel events, derived from direct reporting, patients’ complaints, and other sources. Using a mandatory reporting system,

the New York State Department of Health identified 46 cases in 2 years, suggesting a much higher incidence given the smaller population (one state) and shorter time period.(1) A recent survey of hand surgeons revealed that 20% of the 1000 respondents had operated on the wrong site at least once in their career, and an additional 16% had prepared to operate on the wrong site but realized their error before making an incision.(2) The United Kingdom National Patient Safety Agency has identified a number of wrong site surgery cases in its first year of reporting and is reviewing available solutions.(3) Reporting of any kind is likely to seriously underestimate the scale of the problem, so the true rate is almost certainly much higher than the rates quoted.(4,5)

Analyses of wrong site surgery suggest that problems may occur at almost any point in the patient´s journey prior to surgery and involve a number of contributory factors.(6) Inadequate patient assessment, inadequate medical record review, poor handwriting, reliance solely on the surgeon to identify the site, and poor communication within the operative team are the most immediate problems. In addition, the chance of error is increased when multiple procedures are performed on the same patient, when a team is under time pressure, and when there is a lack of clear policies and organizational controls.(1)

Several organizations, including JCAHO and Department of Veterans Affairs (VA), have produced guidelines aimed at eliminating wrong site surgery. The guidelines systematically address each point where problems can occur.(7,8) More detailed information and guidelines are available on the web sites listed in the Table. The policies are a mixture of standardization and simplification of procedures, combined with additional checking and double-checking by the surgical team. Typically, guidelines require the marking and signing of the surgical site by the operative surgeon (who must also be involved in the consent process), involvement of the patient at the time of marking, verification of a checklist of all records in the operating room (OR), and verbal verification of the site by all members of the surgical team. JCAHO has also suggested that patients should be prepared to check and question the site if necessary. This represents a considerable cultural shift in health care both in admitting the possibility of error and actively involving patients in checking for it. Recently, JCAHO released a Universal Protocol for preventing wrong person, wrong procedure, and wrong site surgery.(7) The VA has implemented their process (8) in 10 pilot sites and received reports that the process was worthwhile, sensible, and likely to reduce error. However, the extent of adoption of this and other campaigns is unknown, and no studies have attempted to compare the various approaches or to determine whether any new risk factors may have been introduced.

In the present case, as far as one can tell, no problems occurred in the routine biopsy, labeling, and preparation prior to surgery. The site was

presumably not marked, but it seems clear that there was a correctly labeled left-side biopsy and corresponding statements in the medical record. The wrong site surgery occurred because the surgeon remembered, incorrectly, that he had biopsied the right side and then chose to ignore the written record and the trainee´s doubts in favor of his own memory. A conflict between one´s own memory and documentary evidence should always raise a red flag. Studies of eyewitness testimony, for instance, have shown that it is relatively easy to introduce false material into otherwise veridical memories (for instance, confusing the clinical information of two patients) and that people express a high degree of confidence in the new memories.(9)

The new wrong site procedures, if followed, would have required the surgeon to sign the site pre-operatively, when he would have had the biopsy results in hand and the patient´s records as a further check. The guidelines also introduce another level of checking within the OR: namely, that all members of the surgical team are involved in the final verification step and the procedure is not started until all concerns are resolved. In this case, the trainee did in fact question the attending physician´s instruction, pointing out that the chart indicated that the positive biopsy was from the left side. However, he was presumably told to proceed as instructed. The trainee then went ahead with what, strictly speaking, was a mutilating operation in the face of his own doubts and documentary evidence that he was acting incorrectly. Whether he was truly reassured by the attending physician´s insistence, or simply abdicated responsibility in the face of a powerful authority figure is not clear.

Criticism might be made here of both the trainee, for not having the courage to request further checks, and of the attending, for not taking the trainee’s query seriously and at least halting the operation while the truth was established. This interaction can also be seen as reflecting the more general problem of authority gradients in clinical teams. In a survey asking whether junior members of a team should question decisions made by senior team members, pilots were almost unanimous in saying that they should.(10) The willingness of junior pilots to question decisions is not seen as a threat to authority but, as in the wrong site guidelines, as an additional defense against possible error. In contrast, in the same survey, almost a quarter of consultant surgeons stated that junior staff members should not question seniors. While strong leadership is necessary in surgery, an unwillingness to listen to junior staff is dangerous. Guidelines by themselves cannot fully address such a deep-seated cultural issue, but can provide a powerful counterweight by mandating and authorizing such questioning across an authority gradient.

Case & Commentary: Part 2

The trainee informed the pathologist that the right side had been removed, and then informed the attending surgeon about the alleged error. The attending surgeon denied that any error had been made; he insisted that the original biopsies had been mislabeled. The surgeon did not inform the patient of the error. When the patient returned for routine follow-up, the surgeon performed a vulvar colposcopy and biopsied the left side. Microinvasive cancer was noted in the biopsies. Shortly thereafter, the patient underwent a second hemivulvectomy to treat her vulvar cancer.

The first, right-sided, hemivulvectomy proved to be unnecessary. The original error was not disclosed at the time, and the patient presumably underwent the second procedure believing that cancer had been discovered on both sides. This raises a host of ethical, practical, and psychological issues. Should the error be disclosed? What principles should guide a decision to disclose? What will the impact of disclosure be on the patient and her family?

Ethically, there is little question that errors leading to harm should be disclosed, unless there are compelling arguments that disclosure is not in the patient's best interests. It is less clear if near misses should be disclosed. In any case, the impact of disclosure must be considered, but so must the impact of not disclosing, which in this case might leave the woman believing that cancer was more widespread than it actually was. Patients who have not experienced errors report that, if a harmful error occurred in their treatment, they would desire full disclosure.(11) Patients who have actually been harmed report a need for apology, explanation, and assurance that preventative action has been taken against future incidents.(12)

Error disclosure for physicians is difficult, even heart rending. They may be anxious about the process itself, the loss of the patient's trust, the effect on their reputation, or litigation.(13) Error disclosure for patients, however, is merely the first step in a long process of adjustment to an injury which, they now discover, could have been avoided.(14)

What impact might disclosure have in this case? To begin with, gynecological surgery is known to have a variety of effects on self image, sexual functioning, and confidence in sexual desirability over and above anxiety and distress associated with possible recurrence of cancer.(15) This woman was subjected to unnecessary surgery that both she and her partner may experience as "mutilation" and that may have considerable effects on sexual functioning, through both anatomical and psychological changes. The disclosure of the error therefore takes place within an already highly emotionally charged context. It will undoubtedly have a substantial impact of its own. Before embarking on disclosure, it is essential to consider the impact on the woman, her partner and family, and future relationships with health care professionals. Disclosing an error that has had serious consequences could be damaging if these longer-term issues are not considered. Error disclosure

must be accompanied by offers of long term support, remedial treatment where possible, and a continuing relationship with the patient and family.

Wrong site surgery is a devastating, costly medical error. Prevention requires application of reliable, fail-safe check systems at multiple points along the patient's journey to surgery and must include all team members. Disclosure of medical errors is a challenging but important feature of providing medical care and must be considered in every case.

Charcoal Lavage of the Lungs

The Case

A 47-year-old man presented to an emergency department (ED) with altered mental status, and was believed to have a probable overdose. He received endotracheal intubation, and, after he was stabilized, the ED staff planned to place a nasogastric (NG) tube to begin charcoal gastric lavage. A nurse passed the NG tube, and an attempt to aspirate gastric contents yielded no return. At that point, the nurse injected a 50-cc syringe full of air through the tube, and the intern reported that he heard a "woosh." Convinced that the NG tube was properly placed by its ease of passage, the confirmatory sound of the air over the stomach, and the presence of the endotracheal tube (with its inflated tracheal balloon), he gave the nurse the go-ahead to inject a slurry of activated charcoal in a sorbitol vehicle through the tube.

Soon after the charcoal infusion, the patient began to cough and developed worsening oxygenation. A chest radiograph demonstrated a new infiltrate in the right mid-lung field just distal to the tip of the NG tube, which clearly was in the right mainstem bronchus. The tube was promptly removed. The patient was treated for aspiration pneumonitis (although the charcoal is relatively inert, the osmotic stress induced by the sorbitol is quite toxic to the lungs), but he developed multiple complications including progressive pneumonia and ultimately died.

The case submitter reported that, in response to this incident, the hospital changed its protocol to require a confirmatory radiograph before anything is infused through a newly-placed NG tube.

Lost in the Black Hole

The Case

A 38-year-old married, monogamous female came to the emergency department with aseptic meningitis. She had a remote history of gonorrhea,

no environmental exposures, and had not taken any non-steroidal anti-inflammatory or sulfonamide drugs. She was admitted to the hospital and cared for by a hospitalist, who suspected that the patient might have acute HIV and ordered a test for HIV quantitative PCR. The test result (positive, with a viral load of 32,000 copies/mL) came back more than 1 week after the patient was discharged, and the hospitalist noted it. However, the laboratory indicated that the batch was "defective" and the test needed to be rerun. The hospitalist never received the new report and, lacking a reminder system, forgot to follow up on the result. Neither the patient nor the primary care physician was notified that an HIV test was pending, so neither of them followed up on this test result. The error was first recognized 6 months later when the hospitalist stumbled upon the original test report while cleaning out a desk.

In fact, the patient´s aseptic meningitis was her first manifestation of acute HIV seroconversion. Although it was unclear whether the delayed notification had adverse clinical consequences (the role of antiretroviral treatment during primary HIV infection is controversial), it caused the patient major emotional distress, delayed referral to an HIV specialist, and raised the possibility of unprotected intercourse during the 6 months during which she was seropositive but unaware of her diagnosis.

Check the Bags

The Case

A 50-year-old man with new atrial fibrillation was placed on a diltiazem drip in the emergency department for rate control. After arriving at the cardiac care unit (CCU), he was noted to be hypotensive and a saline bolus was ordered. The nurse asked a coworker to get her a bag of saline and went to check on another patient. When she returned to the first patient’s bedside, she noticed that an intravenous (IV) bag was already hanging from the IV pole, and thought that her coworker must have placed the saline bag there. Believing the patient required a rapid saline infusion, she opened the IV up, and the solution infused in rapidly. At that moment, her coworker arrived with the 500 cc saline bag, which caused the patient’s nurse to realize, in horror, that she had given the patient an IV bolus of more than 300 mg of diltiazem. The patient suffered severe bradycardia, which required temporary transvenous pacemaker placement and calcium infusion. Luckily, there was no permanent harm.

Intubation Mishap

Case & Commentary

A 17-month-old female infant in the pediatric intensive care unit (PICU) developed acute respiratory failure.

While setting up the laryngoscope and endotracheal tube, the PICU physician gave a verbal order for atropine, etomidate, and rocuronium. Shortly thereafter, but prior to intubation, the infant acutely desaturated. The team realized the patient received the paralytic agent prematurely. She was immediately intubated without difficulty and her respiratory status was stabilized.

Upon review of the event, the team discovered that the nurse, who was new to the PICU, had not realized the medication was a paralytic agent and thus administered it before the intubation tray was ready, resulting in the infant's desaturation. The physician who ordered the medication had not indicated the timing of administration or that the medication was to be drawn up but not given until later.

In this case, a child suffered a hypoxic episode because she was paralyzed prematurely during an urgent, but not emergent, intubation procedure. We will review this case using a human factors approach (1,2), the overall goal of which is to identify threats to patient safety and then devise strategies to minimize the risk to future patients. The steps in the process are listed in Table 1, and a checklist for contributory factor analysis is detailed in Table 2. (Please refer to Figure for explanation of risk priority assigned in Table 2.)

Teamwork and Communication This case illustrates an unfortunately common occurrence in health care: flawed teamwork related to deficiencies of interpersonal communication. Based on work in the business arena (3), Weinger has proposed that effective teamwork in the health care setting requires the presence of the "5 C's" outlined in Table 3. In the present case, one might be tempted to give the team a failing grade on three of the five C's: Competence, Communication, and Coordination. Coordination is dependent on effective communication.(4)

The Evidence for Communication Failures.—In one ICU study, failures of communication between team members accounted for 37% of all errors reported during a 4-month period, yet represented only 2% of task activities documented during a 24-hour direct observation period.(5) In ongoing anesthesia patient safety research in San Diego, CA, communication failures contributed to 16% (20 of 98) of operating room events reported by the primary clinicians when directly queried by a researcher (nearly 90% were reported within 2-4 hours of the end of the case). In a separate study (Weinger, et al., unpublished work), communication or coordination issues played a role in about 11% of 118 actual operating room events captured during more than 700 hours of direct observation and videotaping. At Dartmouth-Hitchcock Medical Center, failures of team communication were identified in

61% of the 42 events that have been reviewed by the Sentinel Event Committee over the last 4 years. Differences in incidence across studies and settings reflect different methods, definitions, and review criteria, and may reflect different interpretations by nurse and physician participants.(6)

Failures of Interpersonal Communication in Health Care.—Although physicians and other health care professionals spend many years learning an impressive array of scientific information and skills, health care curricula largely omit topics such as interpersonal influence and group dynamics, organizational behavior, negotiation, or conflict resolution. The increasing use of standardized patients is a welcome addition to health care professional education but does not address issues of deficient provider–provider communication and coordination.

The increasing complexity of modern medicine means that care is now being provided by teams of individuals. The diversity of modern teams adds to the challenge: individual team members will differ, not only in their training and degrees, but also in their values, needs, and cultural or other expectations. Working effectively as a team member requires training and practice. Perhaps recent changes in expectations of the Accreditation Council for Graduate Medical Education (ACGME) and other health care regulatory bodies about clinician competency in interpersonal skills will begin to address this serious issue.

It´s Not Just What You Say.—*How* you say something will affect whether the intended recipient understands and acts appropriately on the message. In both realistic simulations and actual patient care, it is common to see clinicians bark out instructions (eg, "Get an IV in this guy") without any direction as to *who* should do it. Extensive research in social psychology shows that words, as well as their order and timing, will all affect how other people respond.(7) Vocal cues (rate, tone, pitch, volume, emphasis of speech) typically contain 20%-40% of the overall message. Tannen has documented clear gender differences in both communication style and understanding of what others mean by what they say.(8) Communication is not just verbal—perhaps up to 50% of the "message" is conveyed in nonverbal behavior (facial expression, body posture and movement, eye contact, etc.).(9,10) Effective team communication involves unspoken expectations, traditions, assumptions about task distribution, command hierarchies, as well as individual emotional and behavioral components. Xiao and colleagues recently showed that highly skilled trauma teams communicated in a variety of ways, many of which were nonverbal and implicit.(11) However, nonverbal cues are even more susceptible to misinterpretation, due to changing context or differences in gender and culture.

Taxonomy of Communication Failures.—There are many types of communication failures and many ways to classify them. Fundamentally, they

can be broken down into failures of message transmission and reception. Table 4 provides a comprehensive taxonomy. Work in Crew Resource Management (CRM) has revealed that team communication markedly improves with the use of "read-back" or other techniques to acknowledge that a message has been received and understood.(12)

Clinical Competence Clinical competence involves more than knowledge and technical skills. In the complex care environment, one also needs to know when and how to apply knowledge, solve problems, make good decisions, communicate effectively, and work as part of a team. Clinical experience does not always equate with clinical expertise: with improper training, one can learn very well how to do something incorrectly. Additionally, expertise is not an unchanging personal property but a dynamically varying relationship between environmental demands and that person's resources to cope with those demands at that particular time.(13) For example, an anesthesiologist, who is an accomplished laryngoscopist in the operating room, may find her skills lacking when trying to manage a difficult airway in a remote location with poor lighting, awkward patient positioning, or without the usual equipment and support.

The Importance of Situation Awareness.—In this case, the PICU physician was apparently not aware of the competence of the assisting nurse, nor was he aware of the status of the drugs that had been "ordered" until after the infant desaturated. The accepted term for a comprehensive and coherent cognitive representation of the current clinical situation, continuously updated based on repetitive assessment, is *situation awareness* (14,15), which appears to be an essential prerequisite for safe operation of any complex, dynamic system. In anesthesia, surgery, or critical care, adequate "mental models" of the patient and the associated care environment (clinical facilities, equipment, personnel, etc.) are essential to effective situational awareness. Acute care clinicians must be able to recognize clinical cues quickly and completely, detect patterns of cues, and set aside cues that are distracting or less relevant. Even in less acute settings, situation awareness about the actions, thoughts, and intentions of other team members is critical to effective teamwork.

The Importance of Preparation.—In this case, the induction drugs were administered before the intubation equipment was ready. The patient suffered no harm, but this near miss points to the importance of being prepared for unexpected events. Clinicians need to anticipate the risks of each situation and strive to structure the care environment preemptively to reduce their occurrence and impact. Preparedness is paramount in high tempo, high risk domains like anesthesiology and critical care. Optimal response in crisis situations requires not only availability of the necessary equipment and drugs, but also mental and physical readiness. Excellent clinicians prepare themselves for all possible scenarios and their risks by mentally simulating

what both patients and team members might do (or not do) in different clinical situations.

Designing Effective Interventions to Address Deficiencies of Teamwork and Communication The goal of a formal case review should be to identify threats and facilitate the design of countermeasures, creating enhanced safety for the next patient. Crew Resource Management training, used in the aviation industry to train members of the flight deck, has become a model for team training in some sectors of medicine. David Gaba and colleagues have been instrumental in adopting CRM to the anesthesia domain, termed Anesthesia Crisis Resource Management Training (ACRM).(12,16) High fidelity patient simulation typically plays a key role in CRM-oriented team training because realistically recreating the complexity of the clinical environment helps assure that the behaviors and lessons learned are transferred to real patient care. Such simulators can be calibrated to the needs of the team; some can recreate incidents that provoke performance failures among even the best of clinicians.(17-19) Such simulations give groups a safe setting in which to practice the full range of effective teamwork behaviors such as task allocation, read-backs, closed-loop communication, and clarifying roles and responsibilities for each team member. Simulated exercises are usually videotaped to facilitate the critical structured debriefing sessions in which performance failures are reviewed and lessons learned.

One of the limitations of using simulation more broadly in health care has been the expense of setting up a facility (eg, in addition to a dedicated and usable facility, the cost of a patient simulator will be $30,000 to $200,000, and clinical and video equipment might be $10,000 to $100,000), the cost of conducting simulation courses (including the cost of relieving instructors and trainees from regular clinical duties), and the small number of learners that can have a truly hands-on experience at any one time (typically less than 8 in a group). Nonetheless, many academic medical centers, including ours, have created Simulation Centers to enhance clinical training. Both of our groups have been conducting simulator-based "mock codes." At Dartmouth, simulated pediatric sedation events are conducted to "stress test" various clinical settings where sedation care is provided. Although more than 300 individuals provide this care at Dartmouth-Hitchcock Medical Center, no more than 20 clinicians participate in each mock code. Thus, to broaden the learning from each simulated sedation exercise, videos demonstrating code reenactments are sent to all 300 providers over the hospital internet—essentially an internet debriefing for a large audience. If efficacy can be established, dissemination models like these should prove useful for hospitals and providers unable to afford simulation centers or to support their complex logistics.

Using simulation in the PICU at the Children’s Hospital at Dartmouth, we closely emulated this case in two videos. [Limited by the constraints of the

plastic mannequin simulator, the case involves a 6-year-old instead of a neonate. In addition, we took the creative license to include an additional putative contributory factor (that may or may not have been present in the original case) of parental presence and involvement because this is increasingly common in PICUs and has been suggested to play a role in some accidents.[20]] The first video is titled "Poor Communication" (Video 1) and might be what happened in this case, with the caveats described above. The second video is titled "Good Communication" (Video 2) and is meant to show how communication might have been different if the clinicians had all participated in a team-based CRM course. Take particular notice of how the ICU physician and nurse communication differs (both in terms of confirming that the order was understood and seeking clarification of intent) as you watch the two 3-minute videos.

This case nicely illustrates the fact that errors are increasingly due to failures in communication and teamwork. Traditional training models, such as lectures and readings, can play only a limited role in preventing these errors. Moreover, isolated training silos (training doctors and nurses about teamwork in separate rooms) will not help diverse professionals learn to work together as a team during crisis situations. The use of CRM, video simulations, role-plays, and other innovative training models will be needed to tackle communication and teamwork errors.

Making Do

The Case

A 56-year-old female with dysfunctional uterine bleeding and possible retained intrauterine device (IUD) was scheduled for elective hysteroscopy and dilation and curettage (D&C). Of note, she had recently completed a course of tetracycline for an asymptomatic infection with *Actinomyces israelii* discovered on Pap smear.

After the patient was in the operating room and prepared for the procedure, the team discovered that the equipment typically used for hysteroscopy was unavailable—the case had been listed only as a "D&C" on the operating room (OR) schedule, so the hysteroscopy set had not yet been sterilized after use earlier in the day. To avoid cancelling the procedure, the team borrowed sterile parts from various other hysteroscopy sets.

During insufflation of the uterus, the patient suffered cardiac arrest presumably related to air embolus. The patient was successfully resuscitated. After an 8-day stay in the intensive care unit, the patient was discharged home with no permanent sequelae.

Initially the team attributed the patient’s decompensation to air introduced from the "makeshift" hysteroscopy set, which may not have been a truly "closed" system. However, post-operatively, the patient developed fevers, and blood cultures grew *Actinomyces*. The team then concluded that the event was more likely caused by intraoperative introduction of *Actinomyces*, due to incomplete eradication of this infection pre-operatively.

Did We Forget Something?

The Case

A 76-year-old-man underwent right aorto-iliac aneurysm repair. He developed postoperative fever, initially attributed to ventilator-associated pneumonia. However, the fever persisted and no definite source was identified. He received multiple courses of broad-spectrum antibiotics over a 2-month hospitalization.

Several months after discharge, he presented to another institution with recurrent fever, neurologic deficits, and renal failure. He was diagnosed as having endocarditis with *Candida albicans* on the basis of echocardiography and blood culture results. Despite amphotericin and valve surgery, he died a few weeks after this admission.

Autopsy revealed a surgical sponge in the abdomen around the previous aorto-iliac repair. An abdominal computed tomographic (CT) scan during the previous hospitalization had shown a metallic clip in the area of the graft, but no other abnormalities. The patient had not had any other surgeries.

Shake Well

The Case

A 35-year-old patient on the neurology service was receiving carbamazepine for a seizure disorder. Daily serum drug levels consistently fell below the therapeutic range, which led the physicians to gradually increase the doses. On the seventh day of hospitalization, the patient appeared drowsy, which progressed to stupor, unresponsiveness, and hypotension. For completeness, the evaluating physician added a serum drug level to the other lab tests and was surprised to find the carbamazepine level markedly elevated, in the toxic range.

The cause of the toxic carbamazepine level was assumed to have been an iatrogenic overdose the day of the patent’s deterioration, so a medication error report was filed. When the pharmacist began investigating the report, she noted that the brand of carbamazepine suspension had recently been

changed to a generic formulation that tended to settle out of suspension significantly faster than the original manufacturer's suspension.

After satisfying herself that a dosing error had not occurred on the day of the patient's deterioration, the pharmacist inferred that failure to shake the bottle prior to administration resulted in the initial doses being very dilute. As the others used the multi-dose suspension bottle, the remaining solution became increasingly concentrated, resulting in a toxic dose.

Because the healthcare organization had switched carbamazepine formulations at all its member hospitals, a Continuous Quality Improvement (CQI) process was initiated, which identified a similar medication error at another location. In the second case, a pharmacy technician failed to shake thoroughly a bottle of carbamazepine suspension prior to pouring it into a plastic bottle for dispensing. The nature of the second error was discovered after a sample of the remaining suspension was sent to an independent lab for analysis and found to be highly concentrated.

Code Status Confusion

Case & Commentary: Part 1

60-year-old woman with a long history of severe asthma without prior intubations presented to the emergency department with shortness of breath. Her exercise tolerance had been worsening gradually over 2 months prior to admission, with a marked decrease in her ability to complete her activities of daily living. On physical examination, her blood pressure was 145/85, pulse 85, oxygen saturation of 94%, with a respiratory rate of 22. Her lung exam was significant for diffuse-end expiratory wheezes and decreased breath sounds at the bases. Despite having a long-standing relationship with a primary care physician, the patient had not designated a health care proxy or completed a living will prior to admission.

Hospitalized patients may lose the capacity to make medical decisions. If this occurs, hospital-based physicians must discuss treatment decisions with a surrogate decision-maker, and any decisions they make should be based on the patient's preferences.(1) These preferences could be indicated in a written document such as an advance directive, or in a medical record note, documenting discussions between the patient and primary care physician.

Approximately 75% of patients who present to hospital emergency rooms do not have an advance directive.(2) In the absence of a terminal diagnosis or advanced serious chronic illness, they are even less likely to have completed such a document. Even when completed, such documents are frequently

unavailable to physicians in the hospital. When available, they may be difficult to interpret in the context of specific interventions.

Ascertaining the patient's preferences with respect to resuscitation is particularly important. If a cardiopulmonary arrest occurs, there is no opportunity to ask the patient whether she wants cardiopulmonary resuscitation (CPR) attempted. Moreover, because CPR needs to be instituted immediately to have a chance to succeed, there is no opportunity to ask the patient's surrogate. On a population level, we know that 30% of patients with serious underlying illness do not want resuscitation attempted.(3) However, on an individual level, physicians cannot predict patient's preferences regarding CPR without asking them explicitly. Thus, hospitalists and house officers often need to discuss advance directives with patients whom they have not previously met.

Case & Commentary: Part 2

Upon admission, the intern spoke with the patient about code status. The patient stated that she "would not want to be on a tube to breathe." When asked about CPR, she stated she did not want "shocks to the heart or pressing on my heart." She stated that if her breathing continued to be this difficult and she could not live independently, she would rather not survive. The intern interpreted these statements as indicating the patient's desire for do-not-resuscitate (DNR) status, and called the resident to discuss this issue without filling out the hospital's DNR form.

The medical literature focuses on the concern that patients with serious or terminal illness may inappropriately receive CPR despite its very low success rate and its extreme invasiveness. This case raises the opposite issue: whether patients with highly reversible conditions refuse CPR because they fail to appreciate how effective it is likely to be in their situation. In either terminal illness or readily reversible conditions, discussions between physicians and patients concerning DNR orders and advance directives have several common features.

First, physicians often use vague language. In this case, the patient was asked, "Would you want your life prolonged?" without any explanation that intubation necessitated by an asthma exacerbation is usually effective and temporary. In other discussions, physicians may use such terms as "very sick" or "very serious" and do not clarify what they mean by these terms.

Second, physicians commonly use scenarios to elicit patient preferences regarding future care. In one study of primary care physicians discussing advance directives, 91% presented dire scenarios.(4) For example, doctors typically asked the patient to consider, "If you were sick with a terminal

illness ... if you had something that could never be cured ... and you started to get really, really sick." In contrast, only about half of physicians presented scenarios that involved uncertain outcomes or reversible conditions. The reversible nature of this patient's illness was not discussed.

Third, physicians often miss opportunities to address patient concerns and clarify their values. Many patients say that they would not want life-sustaining interventions if they had little prospect of a good quality of life. Physicians rarely ask what constitutes an acceptable quality of life to the patient, or what counts as a small prospect of benefit. Likewise, physicians rarely clarify what patients mean when they say that do not want interventions that would be a burden. This patient stated that she valued living independently and if she could not do so, she would rather not survive. However, there was no discussion whether she would accept temporary dependence on mechanical ventilation in order to regain her previous level of health. For example, the patient could have been offered a time-limited trial of therapy.

Fourth, when discussing CPR, physicians usually explain the intervention in highly technical terms, without checking whether patients understand the information.(5) Physicians dominate these conversations speaking nearly three-fourths of the time, giving patients little opportunity to ask questions or raise concerns.(5) In this case, we do not know the details of the conversation. However, later developments indicate that the patient misunderstood the effectiveness of mechanical ventilation in her situation.

Finally, even after discussions with physicians, patients commonly have serious misunderstandings about CPR.(6) In one study, patients estimated that survival after CPR is 70%, whereas in reality survival of CPR administered on general hospital floors is about 10% to 15%.(6) When patients were asked to describe CPR, 26% could identify no features of CPR. With regard to mechanical ventilation, 37% of respondents thought that ventilated patients could talk, 20% thought ventilators were oxygen tanks, and 20% thought that people on ventilators are always comatose. Thus although patients could express clear preferences regarding whether they wanted CPR, they often did not understand the interventions to which they were referring. It is likely that the patient in this case envisioned "shocks to the heart" as pre-terminal procedures and, in contrast to many other patients, was overly pessimistic about its success rate for her situation.

Case & Commentary: Part 3

A few hours after admission, the patient had sudden respiratory failure leading to pulseless electrical activity (PEA) arrest. The nurse, who did not know the patient's code status, called a code and CPR was initiated. The code team found the intern's initial assessment, which stated the patient's preference for

no resuscitation or intubation efforts; however, this was not corroborated by the requisite DNR/DNI form. The resident had discussed the case briefly with the intern (including her interpretation that the patient wished to be a DNR), but neither the resident nor the attending had discussed code status with the patient yet. At this point, the patient's blood pressure was 90/palpable with a heart rate of 40 and an O2 saturation of 92% with assisted bag-mask ventilation.

When the patient suffered a witnessed arrest, the team had to decide whether to implement a DNR order. During an asthma exacerbation, there was a high probability that after several days she would be extubated and eventually restored to her baseline clinical condition. In ethical terms, the physicians were concerned that forgoing CPR and intubation would violate the principle of beneficence, which requires physicians to act for the benefit of their patients. However, physicians also need to respect patient autonomy, which allows competent informed patients to refuse any intervention, even life-saving ones.(7) The implicit ethical justification for overriding the "DNR order" in this case is that there was substantial doubt that the patient's refusal of resuscitation was informed. Furthermore, the issue had never been discussed with an attending physician, and no DNR order was written in the medical record. The team appropriately attempted resuscitation.

Case & Commentary: Part 4

The patient did receive cardiopulmonary resuscitation, including medications and chest compressions. In an effort to respect the patient's preference to avoid invasive ventilation, she was started on noninvasive bi-level positive airway pressure (BIPAP) ventilation. Spontaneous respirations returned with BIPAP and the patient was stabilized.

The following day, the patient was alert and was able to express her thoughts about the events of the previous night. She had not realized that intubation could be performed as a temporizing measure. The patient thought that initiation of intubation was synonymous with permanent respiratory support, and stated that she thought the discussion was about whether she would want to be kept alive if she was "a vegetable." Furthermore, she had not realized that resuscitation attempts could be successful. After her experience, she stated she did want aggressive interventions for reversible causes. Her code status was changed to full code.

One should not over-generalize from this unusual case. It is always possible to question whether a patient really understands the possible (or likely) benefits of resuscitation. However, overriding a patient's decision should not be taken lightly. What is ethically required is substantial doubt that the refusal was informed, not just a theoretical concern. In more usual cases, patients who

suffer cardiopulmonary arrest in the hospital do not have a reversible underlying condition or a good prognosis after resuscitative measures. To override a written DNR order, the patient should have a very high likelihood of returning to baseline function after a short intervention.

The housestaff's intuition when the arrest occurred was sound: her refusal did not make sense in her situation, and almost all patients like her would agree to resuscitation. The real lesson here is that the housestaff should have acted on that intuition at the time of the original discussion about resuscitation, by engaging the patient in further discussion to ensure her decision was truly informed.

Taking the perspective of using errors as opportunities for quality improvement, we make the following suggestions to physicians for discussing advance care planning with patients:

- Do more listening and less talking.
- Elicit patients' values and overall goals of care, and then present CPR or DNR as a way of matching appropriate medical treatments with these goals.
- Use simple language to explain CPR and intubation.
- Make clear the alternative to CPR is death, and express, quantitatively or qualitatively, the likely survival after CPR. If applicable, distinguish situations where the outcomes are better, for example resuscitation in the operating room or during conscious sedation for procedures.
- Ask about preferences regarding scenarios with uncertain outcomes, such as successful cardiac resuscitation with resultant severe anoxic brain injury.
- Assess the patient's understanding, particularly if the decision is contrary to what would be expected in similar patients. Thus, if a patient with a reversible condition refuses resuscitation, the physician should ascertain that the patient understands that these interventions have a high chance of success.
- Reassess the patient's goals of care at every hospitalization.

From the point of view of improving health care delivery systems, we make additional recommendations:

- Standardize the DNR order sheet, with separate authorization for CPR, intubation, and vasopressors. Consider including other life-prolonging interventions (ie, tube feeds, antibiotics, dialysis) that may be instituted in patients who will not receive CPR. Remember patients generally need considerable guidance in these options. Be careful not to become too focused on the checklist.
- Teach residents how to elicit patients' preferences and arrive at goals of care.(8) Physicians rarely watch others discuss resuscitation and

advance directives with patients, and trainees are seldom observed in these discussions by more senior physicians. To teach such communication skills, lectures alone are insufficient; trainees need opportunities to practice skills and receive feedback. Role playing, standardized patients, and review of videotaped interviews may be useful.

- Promote interactions between hospital-based and primary care physicians.(9) Perhaps hospital-based housestaff and hospitalists should talk to these physicians before they write DNR or DNI orders. In this case, the outpatient attending physician may have said that the refusal was not like the patient at all and questioned whether she really understood the decision.

A Little Shuteye

The Case

A 3-year-old boy was seen in urgent care for a superficial laceration above the left eyebrow. The pediatrician had heard of the availability of topical skin adhesive that can be used in place of sutures to close wounds (trade name DERMABOND). This was the physician's first experience using this agent, and there had been no training on its proper use in the department. The wound was close to the eye, the child squirmed during the application, and no eye protection was used during the procedure. After the procedure, the physician realized that the child could no longer open his eye, which had been partially sealed shut. An ophthalmologist evaluated the child the next day, and fortunately, there was no permanent injury.

Feeling No Pain

The Case

A 33-year-old female underwent hysterectomy for refractory endometriosis. For pain post-operatively, the patient was placed on a Patient-Controlled Analgesia (PCA) pump containing morphine sulfate. Three hours after her transfer to a gynecology floor, the patient began complaining of severe frontal headache, nausea, and vomiting. Nurses attributed these symptoms to post-operative pain and the effects of the morphine. The PCA pump was continued, despite her continued complaints of headache and relatively mild incisional discomfort. The patient became progressively drowsier and her respiratory status declined. Luckily, the pulse oximeter alarm was activated when her oxygen saturation fell, and the PCA pump was discontinued. At the time of the discontinuation, the patient's O2 saturation level was 76%. At that point, clinicians realized that she was actually suffering from an adverse reaction to morphine. Further investigation of the patient's prior medical history revealed

similar complaints with prior administration of meperidine hydrochloride (Demerol), but these had not been noticed in her chart, elicited on pre-operative history, nor flagged as an adverse reaction or “allergy.”

Check the Wristband

The Case

The patient was a 28-year-old female awaiting ambulatory surgery. She was very anxious about the impending surgery. The patient spoke English and appeared to be of average intelligence.

In this institution, standard practice was that ambulatory surgery patients walked to the operating suite accompanied by a Registered Nurse (RN). The case was reported to AHRQ WebM&M by this circulating nurse, who noted, *“I went to the surgical day care unit to meet my next patient. I picked up the chart that was next to this patient. The chart was correct for my next patient. I verbally stated the patient's name and this woman confirmed her name. She also confirmed other information, including the [type of] surgery.”*

In retrospect, the nurse realized that she herself had supplied much of the critical information for patient identification, rather than asking the patient open-ended questions and insisting that the patient provide correct identifying information. And yet, the patient affirmed all the nurse’s queries. Upon reflection, the nurse realized, *“This patient was so anxious she was not actually hearing much of anything I said to her. She continued to agree and confirm whatever I said to her. The error on my part was that I stated her name, and did not check her wristband.”*

At the end of the identification procedure, the nurse walked the patient to the operating room (OR) suite and had her positioned on the OR table. The certified nurse anesthetist checked the patient's wristband and alerted the nurse to her error—the chart the RN had picked up was not that of the correct patient but had inadvertently been left next to her. The nurse noted, *“I was shocked. I apologized, explained she was in the wrong room, and asked that she return to the waiting area. I had to take the patient off the OR table and return her to the surgical day care unit.”*

Luckily, the error was caught and the patient was not harmed. As the nurse recalled, *“I learned a serious lesson, which I certainly had been taught in nursing school, which is to always check the wristband. I don't know just how far this mistake would have gone, because the patient is frequently asleep when the surgeon enters the suite. I now reinforce the importance of always checking the wristband whenever I have an opportunity to with my colleagues.”*

Bleeding Risk

The Case

A frail 78-year-old woman fell at home and fractured her left hip. Her past medical history included atrial fibrillation, hypertension, coronary artery disease, and stroke. The surgical repair and post-operative course were uneventful. The patient was discharged to a skilled nursing facility (SNF) for physical therapy on low-molecular-weight heparin, with a plan to initiate warfarin once it became clear that that she was not at high risk for falls.

Two weeks into her admission at the SNF, the patient's physician began warfarin therapy at 5 mg daily. An INR level taken 3 days later was 1.5. Heparin was discontinued and warfarin was increased to 6 mg daily. An INR level was not ordered to be drawn for 7 days, at which time it was at a critical level of 20 (therapeutic range 2-3). The physician discontinued warfarin, but no other therapy was administered to reverse the anticoagulant effect. A repeat INR 3 days later was 12. A one time order for 10 mg of Vitamin K intramuscularly (IM) was administered. A repeat INR was ordered 2 days later, at which time it was 4.4—elevated but no longer critical. Two days after that, the INR was subtherapeutic at 1.4. At that point, the physician reinitiated warfarin at the original dosage of 5 mg daily. The INR did not become therapeutic for another 12 days, presumably because of the Vitamin K effect.

The Dangerous Detour

The Case

Following an overdose of alcohol and Ativan, a 26-year-old woman was admitted to the Medicine service for observation after being placed on a 72-hour hold by Psychiatry. Per hospital policy, a 24-hour sitter was placed with the patient.

The patient was to be accompanied to Radiology for a chest film and asked to go to the bathroom first. The transport and sitter were in the room when the nurse left the room to get the chart, which would go down with the patient. The sitter and transporter began to chat. The nurse returned and became concerned that the patient was still in the bathroom. She opened the bathroom door to find the patient with her gown tied around her neck and the door hinge. The patient was standing on the upside-down garbage can and was seconds from stepping off and hanging herself. The patient was unharmed; she was stopped in time.

XL or Smaller?

The Case

With a history of hypertension and chronic renal failure secondary to hemolytic uremia syndrome at age 3, a 14-year-old boy presented to the emergency department with dehydration secondary to gastroenteritis. Though his gastroenteritis had resolved, he was admitted due to worsening renal function and out-of-control hypertension.

The intern admitting the patient spoke with the renal fellow to ask for advice concerning the hypertension, which now measured 160/95. The renal fellow recommended giving the patient Procardia® (nifedipine) 30 mg by mouth. The intern wrote an order for the medication. Approximately 45 minutes later, the nurse paged to inform the intern that the medication had been given and inquire how often the blood pressure should be checked. The intern's senior resident happened to be present. As the scenario was discussed, the senior realized that 30 mg of Procardia, not Procardia XL® (extended-release nifedipine), had been given. The nurse was asked to check the blood pressure every 3 minutes, and the residents immediately went to see the patient.

Within 5 minutes, the patient's blood pressure had decreased to 110/60. IV fluids were started and the renal fellow was contacted. Glucagon was brought up to the bedside but did not need to be administered, as the patient's blood pressure did not drop below 100/50 and he remained asymptomatic while supine.

Upon further discussion between the fellow, intern, nurse, and pharmacist, several points emerged. When renal specialists refer to the extended-release drug Procardia XL, it is often called Procardia 30 mg, to differentiate it from Procardia 5 mg, the instant-release formulation used in hypertensive crisis. The pediatric intern had minimal experience dealing with hypertensive medications, and did not recognize the difference when the fellow recommended Procardia 30 mg. The nurse had consulted a drug reference and had seen that Procardia was typically given as 5 mg, but that a 30 mg dose was available. She then discussed the order with the pharmacist. The pharmacist had seen that the medication was written as Procardia, and not as Procardia XL. However, after talking with the nurse, who confirmed the patient had significant hypertension currently refractory to his normal hypertensive medications, he concluded that Procardia was indeed the desired medication.

Not a Miscarriage

The Case

A 32-year-old woman, gravida 3, para 1, with a history of Type 2 diabetes mellitus on metformin, presented at 7 and 2/7 weeks by last menstrual period

(LMP). The patient reported a history of a primary low transverse cesarean section and a bicornuate uterus. Formal ultrasound revealed an intrauterine gestational sac, with no embryo, and a bicornuate uterus. Beta hCG was 1009 mIU/ml. Hgb A1C was 9.4 g/dL. Her metformin was discontinued and insulin was started.

She was scheduled for a repeat scan approximately 48 hours later, when her hCG would be expected to be over 2000 mIU/ml. At that time, she was spotting, and instead presented to the gynecology clinic. She was seen by an intern who presented the case to an attending and mentioned that the patient had already been found to have an intrauterine pregnancy (IUP) on formal sonogram, but failed to mention her history of a bicornuate uterus. They performed a transvaginal ultrasound, found an empty uterus with a thin stripe, and diagnosed the patient as having a completed spontaneous abortion. At that time, they restarted her metformin.

Several weeks later, the patient went to the family planning clinic for follow-up on a Friday afternoon, at which time a urine pregnancy test was positive. An hCG was checked and found to be 40,000 mIU/ml. She was given a lab slip to return on Monday (before the results were back), as it was unclear whether the urine pregnancy test was positive from an ongoing pregnancy or if she was pregnant again. Her hCG increased, and she was again seen in the gynecology clinic that day, where an ultrasound confirmed a 13 and 3/7 week IUP in the right uterine horn. The patient was then admitted for insulin therapy.

Missed Appendicitis

Case & Commentary: Part 1

A 37-year-old woman with no past medical history went to the emergency department (ED) complaining of vomiting and periumbilical abdominal pain for 6 hours. On physical examination, she was afebrile, with a blood pressure of 110/70 and a heart rate of 85. Her abdomen was soft, without rebound or guarding. She was diagnosed with gastroenteritis and discharged with antiemetics. She was told to return for persistent vomiting, pain, or new fever.

Abdominal pain is a common chief complaint in emergency departments, accounting for more than 6% of the approximately 100 million ED visits in the United States each year.(1,2) The most common surgical cause of abdominal pain is appendicitis, affecting 7% of people during their lifetime.(2,3) Of all ED patients with abdominal pain, however, only 1%-3% will have acute appendicitis, many of which will present atypically.(1,2) Consequently, clinicians may become accustomed to ruling out appendicitis rather than ruling it in, eventually resulting in decreased likelihood of making the diagnosis. To combat this effect, clinicians can adopt guidelines (formal or

informal) to prompt consideration of highly morbid diagnoses, such as appendicitis, ectopic pregnancy, and diabetic ketoacidosis.(4) Although the frequency of misdiagnosis of appendicitis ranges from 20% to 40% in some populations, implementation of a diagnostic guideline was shown to reduce the misdiagnosis rate to about 6% in one study.(5)

Given the difficulty in diagnosing appendicitis, it would be a mistake to assume that lack of objective signs or the presence of atypical historical or laboratory features rules out serious underlying disease. For example, only a minority of patients with appendicitis will present with the classic history of abdominal discomfort migrating from the epigastrium to the periumbilical region on to the right lower quadrant. Although the white blood cell (WBC) count will be elevated in 70%-90% of patients with acute appendicitis, this test is neither sensitive nor specific enough to rule in or exclude the disease.(6,7) The presence of pain in the right lower quadrant, abdominal rigidity, and migration of pain from the periumbilical region to the right lower quadrant increases the likelihood of appendicitis.(7) Although often atypical, the history and physical exam can be helpful in assessing a patient for appendicitis. For example, the presence of vomiting before the onset of pain makes appendicitis unlikely, as does the absence of right lower quadrant pain, guarding, or fever.

Physicians who wait for clear, easily recognizable signs will miss many diagnoses. Gastroenteritis may cause crampy, intermittent pain, or may result in muscular pain from vomiting, but should not cause significant continuous pain. This diagnosis should not be made unless the patient clearly exhibits symptoms of diarrhea, vomiting, nausea, crampy abdominal pain, and/or fever, which did not appear to be true for this patient. The presence of pain should increase suspicion for serious underlying conditions, including appendicitis, even if vomiting is present. If uncertain, the clinician must decide whether imaging or continued inpatient observation is required, or whether the patient is safe to return home. In either circumstance, clear discharge instructions should be provided.

When abdominal tenderness is present, a computed tomography (CT) scan can enhance the diagnostic accuracy of appendicitis. However, if the suspicion for acute appendicitis is high, surgical consultation should not be delayed. Anecdotal but widespread concerns have been voiced about potential overreliance on CT scan by emergency physicians and surgeons. The time, expense, and radiation associated with CT is not warranted when the diagnosis can be reliably made or otherwise excluded. For example, the diagnosis of appendicitis in the man with classic right lower quadrant tenderness and other typical signs and symptoms does not require confirmatory CT scan. However, for women, in whom ovarian pathology can mimic appendicitis, and for men whose diagnosis is less certain, obtaining a CT scan is appropriate.

Although sensitivity of up to 100% has been reported for CT scans of the appendix (6), in typical practice the sensitivity is more likely to be 80%-96%.(8,9) Thus, clinicians should be aware of the possibility of false negative scans. Conversely, the specificity of appendiceal CT is not perfect. A Bayesian approach is needed: widespread use of CT in low-risk patients will lead to significant numbers of false positive test results and unnecessary appendectomies. In some cases, a period of inpatient or outpatient observation is warranted despite the CT report. Patient teaching (including thorough discharge instructions) and good communication are the routes to minimizing error.

The best approach to evaluating an ED patient with abdominal pain is to maintain suspicion for early disease, even disease not yet diagnosable, and instruct the patient accordingly. A nonspecific diagnosis of "abdominal pain" can be appropriately followed by a discussion with the patient surrounding "red flag" signs and symptoms as well as the expected course. If abdominal tenderness is absent and there is no justification for CT scan or extended hospital observation, careful instructions must include warning signs of more serious disease. Then, if the patient returns with appendicitis, the initial encounter cannot be counted as a failure, but as a success.

Case & Commentary: Part 2

The patient presented to her primary care physician's office 2 days later with complaints of persistent abdominal pain; her vomiting had resolved. Her primary physician called the emergency department to obtain the report. On exam, she was afebrile with normal vital signs. She had a diffusely tender abdomen with some localization around the umbilicus and an unremarkable pelvic examination. A transvaginal ultrasound was scheduled for the following week. The patient was sent home, with instructions to take naproxen for the pain.

Diagnostic assumptions and prior reasoning of others can be carried along, unchallenged when the facts and conclusions of previous assessments are absorbed into subsequent diagnostic reasoning. This cognitive error of "anchoring" is a common source of emergency department error, and error in medical care more generally.(10) In the emergency department, conclusions and assessments of paramedics, nurses, and other physicians initiate assumptions about both acuity and diagnosis. An initial error can be propagated if not reassessed, leading to delayed recognition of serious disease or even mistaken diagnoses. Transitions of care are high-risk points for error, allowing insertion of "pseudo-information," and enabling "posterior probability error," in which diagnostic probability assessment is influenced by preexisting diagnoses.(11)

Before final patient discharge, the clinician must stop and think broadly about the case in order to minimize cognitive error. To avoid such errors, expert clinicians apply “metacognition.”(12) The caregivers ask themselves, “Given the same set of facts and circumstances, is there an alternative explanation that may be more accurate? Have all possibilities been taken into account? Are all issues properly addressed?” Applying this “big picture” assessment can prevent error.

Diagnostic error often occurs when patients present atypically.(2) Adverse events correlate with false-negative determinations. The route to improving diagnostic decision-making in ED patients with abdominal pain is to maximize diagnostic sensitivity by careful consideration of the possibility of appendicitis.

Case & Commentary: Part 3

The next day, the patient returned to the ED with persistent pain. She was seen by the same ED attending, who then asked a colleague to evaluate the case. This second ED attending performed a pelvic exam and ordered a CT scan of the abdomen and pelvis. The CT revealed a perforated appendix (Figure 1). The patient was seen by general surgery and it was decided not to take her to the operating room immediately due to the peritonitis. She was admitted and started on IV antibiotics. Her hospital stay was prolonged due to ileus. On hospital day number #8, her WBC count began to rise. A repeat CT scan revealed an intraabdominal abscess (Figure 2) “the size of an orange.” The patient underwent percutaneous drainage by interventional radiology. On hospital day #13, she was discharged to home with a plan to follow-up for elective appendectomy.

Appendiceal perforation increases the risk of wound infection, abscess formation, sepsis, wound dehiscence, pneumonia, prolonged ileus, heart failure, and renal insufficiency. Perforation leads to longer hospital stays and delayed complications such as bowel obstruction. In women, there is a five-fold increased risk of infertility.(2,13)

In lieu of a guideline to ensure consideration of key diagnoses, clinicians can adopt rules of thumb for when to step back and ask for help from a consultant or, as in the present case, a colleague. Diagnostic decision making is a probabilistic exercise that can never be perfect. Recognizing the potential for cognitive bias from prior evaluation, it was wise and admirable to obtain the input of a colleague on the second visit. Physicians are trained to be solitary clinicians, fully accountable as individuals, but tasked to work as members of a team, without training in teamwork skills. The ability to access a colleague’s expertise is critical at any stage of training or experience.

Case & Commentary: Part 4

Shortly after discharge, the abdominal pain returned. The patient returned to the ED and underwent a repeat CT scan, which revealed a small bowel obstruction. The patient went to the operating room the next day for lysis of adhesions and appendectomy. Eight days later, the patient was discharged home. She has returned to her previous state of health.

Emergency physicians often do not know the outcomes of patients. Experience does not lead to expertise, only feedback does. Implementing ways to increase feedback will enhance quality and may minimize error.(14) Especially in the emergency department, the presence of supportive feedback loops can promote quality and safety.

To enhance safety in the emergency department, a Center for Safety in Emergency Care has been established.(15) This group has formed because of the recognition that the ED is a complex, difficult, and error-prone environment marked by excessive cognitive burden, distractions, interruptions, and time pressure. Identifying optimal practices that maximize safety is an important undertaking. If we are truly going to improve ED safety and quality, we must account for all of these pressures, distractions, and challenges. The safest ED systems include highly trained caregivers, both doctors and nurses, working as a team, utilizing good communication techniques. Interruptions, computer demands, forms, documentation, phone calls, interpersonal conflicts--these all distract from an attentive, thorough, and therapeutic relationship with the patient. This relationship is critical as it forms the foundation of high quality, safe, and satisfactory patient care.

Minimizing misdiagnosis of appendicitis has always been and will remain a challenge, requiring an enlightened system of care as well as informed, expert caregivers.

Inappropriate Antibiotic Use

The Case

A 41-year-old woman presented to the hospital with acute renal failure, which came to be diagnosed as a first presentation of systemic lupus erythematosus (SLE). During the hospitalization, she developed additional complications of SLE including cerebritis, hemolytic anemia, and thrombocytopenia.

After 2 weeks in the hospital, the patient was given vancomycin and piperacillin/tazobactam for altered mental status and leukocytosis of 19,000. A few days later, antibiotics were changed to vancomycin and levofloxacin for persistent leukocytosis and low-grade fevers. Multiple cultures from urine, blood, and sputum yielded no organisms, but the patient was kept on antibiotics due to fevers. Although no clear source of infection was identified,

antibiotics were continued for 3 weeks, at which point her fevers spiked to 38.5°C. At that time, a single blood culture grew vancomycin-resistant *Enterococcus faecium* (VRE), as did a central line catheter tip. Furthermore, urine cultures grew more than 100,000 colonies of *Candida glabrata*.

The patient received a consultation from an infectious disease (ID) specialist, who recommended that all antibiotics be discontinued. Within 24 hours, the patient defervesced. She remained hemodynamically stable and underwent further treatment for her SLE.

Additional information: Although the ID consultants would have preferred to treat the VRE with linezolid, the patient's severe thrombocytopenia and anemia prohibited its use. Thus, she was given doxycycline, a second-line agent for this organism, and had her central venous catheter discontinued. A repeat blood culture grew VRE, which necessitated removal and re-placement of yet another central venous catheter. In an attempt to clear colonization of C glabrata*, multiple Foley catheters were changed, and the organism eventually was eliminated. Initiating immunosuppressive treatment for the patient's SLE had to await eradication of the resistant organisms.*

Suicidal Man With Gun

The Case

The patient is a 36-year-old man who came to a psychiatry clinic for outpatient evaluation of severe depression that had persisted for nearly 2 years. On initial interview, the patient reported chronic thoughts of suicide, stating "If I had a good way [to kill myself], I'd have done it already." On screening for suicide risk factors, the patient admitted to possessing a handgun. He denied active plans for suicide, including using the gun, because "A friend or family member would have to clean up the mess."

The attending physician and resident performing the evaluation assessed the patient as at chronic risk for suicide, but not acute risk, and noted that prompt removal of gun from the patient's possession was paramount to his safety. Both also agreed that building a treatment alliance would be a critical factor in accomplishing that goal. For the patient's depression, the treatment plan included starting an antidepressant (citalopram) as well as psychotherapy.

The patient resisted plans to remove the handgun and refused multiple disposition plans proposed by the resident and the resident's supervisor (who was not the evaluating attending physician during the initial assessment). Suicidal ideation continued and, as time passed in treatment, the supervisor

viewed him as a significantly higher risk to complete suicide than the resident did. Discussions with other faculty and the clinic's risk manager ensued in an effort to delineate the resident's legal options to remove the gun from the patient's possession. Unfortunately, they were not able to develop a clear pathway to removing the handgun. The resident felt that forcing the issue legally would cause the patient to feel abandoned and unsafe, with a strong possibility of either suicide or termination of treatment (with concomitant increased risk of suicide). The supervisor felt that the institution's primary responsibility was to keep the patient safe, and the longer it took to remove the gun, the more at risk the patient was for an adverse outcome. Both resident and supervisor agreed that prior to exploring any emotionally sensitive issues in treatment, the gun had to be removed.

The gun was eventually removed from the patient's residence, but it required nearly 3 months to achieve this goal. Though no harm occurred, this case was a "near miss," given the prolonged exposure of a potentially suicidal patient to such an obvious hazard.

Central Line Clot

Case & Commentary: Part 1

An 8-month-old girl had been in the intensive care unit for 6 days for treatment of septic shock secondary to meningococcemia, and was ready to be transferred to a general pediatrics ward. In preparation for transfer, the nurse flushed the patient's central venous catheter with heparin and "hep-locked" the line. Within minutes, the infant became cyanotic and apneic. A full code ensued and after a brief time, the patient was stabilized with a blood pressure of 95/55, heart rate of 120, a RR of 35, and an O2 sat of 90% on 100% non-rebreather.

Manipulation of central venous catheters can lead to arrhythmias, venous air embolism, and thromboembolism.(1) If the tip of the catheter is in the heart, irritation of the cardiac conducting system by the catheter can cause premature atrial and ventricular contractions and arrhythmias. Although rhythm disturbances can lead to cardiac arrest requiring resuscitation, this usually occurs in children with depressed cardiac function and/or abnormal electrolytes.

For the infant in this case, the acute onset of a high O2 requirement raises the suspicion of sudden embolism of air or clot. Immediate aspiration of the central venous catheter, ideally with the patient positioned with the right side up, can help diagnose and treat venous air embolism. This maneuver would be less effective if performed after CPR, such as in this patient, because it is likely that any air would be dislodged by the chest compressions. In this

patient, venous thromboembolism must be strongly suspected because she is recovering from a hypercoagulable state; meningococcemia is associated with acquired deficiency of Protein C.(2)

Pulmonary thromboembolism is reported much less frequently in infants and children than in adult patients, with scattered case reports and autopsy studies in the literature.(3) It is not clear if this is due to a true lower incidence or underdiagnosis. Radiographic studies for pulmonary embolism are not always readily available in children's hospitals. Thus, therapeutic anticoagulation is not recommended without very high suspicion of or confirmation of a clot or pulmonary embolism. In this patient, the suspicion of pulmonary embolism is high, and starting anticoagulation with unfractionated heparin while further studies are pending would be acceptable but not mandatory. If this infant did not regain hemodynamic stability, it would be prudent to obtain an emergent echocardiogram to evaluate the function of the right ventricle, looking for evidence of septal deviation and pulmonary hypertension. This would be evidence of submassive pulmonary embolism that may require thrombolytic therapy after confirmation.(4)

The gold standard test for diagnosing pulmonary embolism is a pulmonary angiogram.(Figure 1) Alternative tests are spiral computed tomography (CT) (Figure 2) and ventilation-perfusion (VQ) scan.(5) (Figure 3) In adults, spiral CT has been shown to have good sensitivity for diagnosing large, centrally located pulmonary emboli and good specificity when read by experienced radiologists.(6) Because pulmonary embolism is rarely reported in infants and children, many pediatric radiologists do not have experience interpreting spiral CT scans. No studies have been done to evaluate the performance of spiral CT in infants and children for diagnosing pulmonary embolism. Ventilation-perfusion scans can be useful if the patient has relatively normal lungs. Areas of atelectasis or infiltrate can hinder accurate interpretation as blood flow to those areas may be constricted due to decreased ventilation. Because pediatric angiograms are rarely performed, they are not always readily available. Therefore, despite the limitations of spiral CT and VQ scan, these are often the first-line diagnostic studies. A readily available study that may rule out the diagnosis of pulmonary embolism in low-risk patients is a negative D-dimer test.(7) However, this test has not been validated in children, and due to poor specificity, the test cannot be used to confirm pulmonary embolism. In this case, the patient may have a positive D-dimer because of her meningococcemia, and therefore the D-dimer result may not help diagnostically.

Case & Commentary: Part 2

A spiral CT revealed multiple pulmonary emboli. Anticoagulation therapy was started. The patient improved and was discharged home several days later without sequelae from this event.

The coagulation system of prepubertal children is different from that of adults, making spontaneous clots less likely.(8) The incidence of DVT and pulmonary embolism is not well studied in children. One prospective study of 59 hospitalized children with two or more risk factors identified only one patient with a DVT.(9) A retrospective study of pediatric trauma patients identified three cases of DVT in 2,746 admissions.(3) The incidence in the critically ill pediatric population is not known. Almost all deep venous clots in neonates, and one-third in infants and young children, are related to central venous access devices.(10) Catheter-related DVTs are reported in 8% to 25% of infants and children in the ICU, as detected by ultrasound.(11,12) Even more may be seen by venography, a more sensitive test for detecting DVT. However, other factors also put children at risk including congenital or acquired abnormalities of anticoagulant factors including Protein C, Protein S, antithrombin III deficiency, Factor V Leiden mutation, and other medical comorbidities.(Table 1) This patient had at least two risk factors, including acquired hypercoagulability from meningococcemia and a central venous catheter.

It is unclear how many catheter-related thrombi result in pulmonary emboli in children. This is partly because no prospective studies have been done performing spiral CT, VQ, or angiogram in pediatric populations with documented DVT. A more commonly detected problem is thrombus propagation from the tip of the catheter, ultimately resulting in inferior vena cava or subclavian vein occlusion.(13) Clinically, this can lead to swelling and discoloration of the extremity for femoral catheters or swelling of the head or arm for subclavian or internal jugular catheters. For most otherwise healthy children, catheter removal and anticoagulation results in recannulation of the vessel and/or good collateral blood flow over time. However, clotting of the major vessels is a serious problem for chronically ill children who require repeated central venous access, and postphlebitic syndrome can develop.(13) Registries of serious thrombotic complications in infants and children have been developed in Canada and the Netherlands.(10,13,14) These registries show that DVT in infants and children can have very serious morbidity. Although registry data has serious limitations in assessing actual incidence of these severe complications, pediatric intensivists are now becoming more concerned about catheter-related thrombosis and are looking at ways to prevent it.

To date, the best evidence for preventing catheter-related thrombosis in children supports use of heparin-bonded central venous lines.(11,12) A single-center randomized controlled clinical trial and a before-after trial have shown that heparin-bonded catheters not only markedly decrease the incidence of thrombus formation but also decrease the incidence of catheter-related

infection.(11,12) Low-dose heparin flushes (10 u/ml) through the catheter are not beneficial for adults and probably would not be for children.(15,16) Higher doses may be effective but could result in systemic anticoagulation in children. Dosing of low molecular weight heparin (LMWH) in children is similar to the adult population.(17,18) However, there have been no clinical trials evaluating LMWH for DVT prophylaxis in this population. Since other measures to prevent DVT such as pneumatic compression boots and compression stockings are available only in adult size, these measures are unsuitable for neonates and children.

In conclusion, lack of strong evidence (Table 2) makes it difficult to write practice recommendations for prevention of DVT in prepubertal children. There is not enough data, even in adult patients, to determine whether thrombus associated with central venous catheters is preventable with heparin. A multicenter randomized clinical trial is needed to confirm whether heparin-bonded catheters or heparin in the infusate should become standard of care to prevent DVT. Until adequate data is available, it would be risky to write practice recommendations, as heparin is not without side effects. For adolescents, evidence-based recommendations for prophylaxis, diagnosis, and management that are available for adult patients can be applied. Once DVT or pulmonary embolism is recognized in a young child, anticoagulation and close follow-up are required.

Ectopic or Not?

The Case

The patient is a 24-year-old woman, gravida 4, para 1, ectopic 1, at 6 weeks from her last menstrual period. She presents to the emergency department with a 3-day history of vaginal spotting and dull left lower quadrant pain. Her history is remarkable for pelvic inflammatory disease at the age of 22 followed by an ectopic pregnancy requiring right salpingostomy one year later. She is sexually active with one male partner and uses condoms inconsistently.

Examination shows normal vital signs, a benign abdominal exam, and a pelvic exam showing scant blood in the vagina, a closed os, a slightly enlarged uterus, and a minimally enlarged and mildly tender left adnexa. Rectal examination confirms these findings. Her hematocrit is 36%, hCG 12,206 mIU/ml, and her blood type is A positive. An ultrasound showed a thickened endometrial stripe but no fluid collection or gestational sac, and a 2-cm left adnexal cystic structure distinct from the left ovary with no fetal pole identified.

With the diagnosis of repeat ectopic pregnancy, the patient was given methotrexate 50 mg/m^2 IM and discharged home with precautions to return

for increased pain, bleeding, or signs of hypovolemia. She returned 4 days later to the emergency department for worsening pain. Her follow-up hCG was 13,000 mIU/ml. The on-call gynecology team reviewed her work-up and decided to perform a uterine aspiration, which yielded copious tissue but no apparent villi. The patient was then offered surgical management of her ectopic pregnancy. Laparoscopy revealed a 3 x 4 cm left ampullary ectopic and 300 cc hemoperitoneum. The contralateral tube appeared normal and a left salpingectomy was performed. The patient was discharged home the next day and her hCG showed an appropriate decline.

Bloody BP Cuff

The Case

Patient #1, a 28-year-old male, was a trauma patient following a motor vehicle collision into a cement pillar. Patient #1 was in the trauma bay with massive injuries and profuse bleeding. The blood pressure cuff (which was partly fabric and partly nylon) was saturated with so much blood that it could be wrung out. Patient #1 was taken to surgery where he coded and died about an hour later.

Patient #2, a 24-year-old female, was also in a motor vehicle collision and had cuts over her upper body from glass shattered in the crash. Patient #2 was placed into the same trauma bay vacated by patient #1. The same blood-saturated cuff was placed onto her arm, with no regard for universal precautions.

A nurse noted that the same bloody cuff was used from patient to patient. This observation was received by other staff members with a shoulder shrug. Several weeks later, a letter from the medical examiner revealed that Patient #1 was HIV and Hepatitis B Virus (HBV) positive and that the collision was a suicide.

The Dropped Lung

The Case

A 79-year-old woman was admitted for hypoxia and shortness of breath. Two weeks prior she had been hospitalized for dyspnea and was found to have multiple bilateral pulmonary nodules on chest x-ray and a small left-sided pleural effusion felt to be consistent with widely metastatic cancer. The patient refused a work-up and was discharged to a skilled nursing facility (SNF). Increasing dyspnea and oxygen desaturations at the SNF prompted her return to the hospital. In the Emergency Department, the patient was moderately dyspneic with a respiratory rate of 25 and an oxygen saturation of

85% on room air and 97% on 6-Liter nasal canula. Chest x-ray again demonstrated nodules on the right side, but her entire left lung field was now completely “whited out.”

The residents caring for the patient interpreted the white-out as a large pleural effusion, and diagnostic thoracentesis was attempted with return of only 25 cc of yellow fluid. A repeat chest X-ray showed a small lucency at the apex, which they interpreted as improved aeration after removal of fluid. On hospital day two, the initial chest x-ray was read out by the radiologists as left lung collapse (not effusion) with mild leftward deviation of the trachea. The post-procedure film was interpreted as persistent collapse, now accompanied by a small apical pneumothorax.

The patient’s pneumothorax ultimately resolved with conservative treatment, and she received palliative care for her cancer.

The 2-Week Itch

The Case

A 40-year-old woman with bipolar disorder (on trazodone) came to her primary care physician with new urticaria. She received a handwritten prescription for Zyrtec and Atarax.

The handwriting on the prescription was not unduly messy, but the pharmacist dispensed Zyprexa instead of Zyrtec.

At the follow-up visit for her urticaria 2 weeks later, the physician asked if patient was taking her medications as directed because the symptoms hadn’t improved. She was specifically asked about the Zyrtec, at which point patient stated that she was not taking Zyrtec, but was taking a different medication—Zyprexa. As was her habit, the patient had brought all of her pills to the visit, so when the provider asked to see them, the error was immediately recognized.

The patient took the medication for about 2 weeks, with no adverse sequelae. Antipsychotic treatment lowers the seizure threshold and could have increased the severity and/or frequency of epileptic episodes, but this was not observed in this patient.

Medication Overdose

The Case

A 15-year-old boy with end-stage AIDS was admitted to the pediatric ICU with mental status changes. He was diagnosed with status epilepticus and started on a loading dose of IV phenytoin.

In the step-down unit, the resident wrote an order for a maintenance dose of phenytoin. The order was written as mg/kg/d without specification that 'd' meant day vs. dose. As a result, the patient received approximately three times the indicated dose. Later that day, a pharmacist called to alert the resident to his mistake. The subsequent phenytoin level was 98 (therapeutic range 10-20).

Administration of phenytoin was held until the level was therapeutic, and the patient's mental status gradually improved. He had no further seizure activity and ultimately his mental status returned to baseline. He was discharged back to a chronic care facility.

Premature or Overdue?

The Case

A 32-year-old woman, gravida 3, para 1, presented for prenatal care at 24 weeks. Her past medical history was unremarkable, and results of her prenatal laboratory tests were normal. On physical examination, she was moderately obese and had a fundal height of 24 cm. Fetal heart tones were about 130 per minute. Routine prenatal care was planned.

The patient missed several ultrasound appointments, but did have several additional prenatal physical examinations that indicated normal growth in fundal height, up to a 41-week size. The physicians recommended that the patient begin post-dates surveillance with twice weekly NST/AFI (Non Stress Test/Amniotic Fluid Index) at 41 weeks, but she missed her first appointment. At 42 weeks, she was admitted for post-dates labor induction using misoprostol and oxytocin. Twelve hours into the induction, examination showed 3 cm cervical dilatation. The patient's care was handed off to the next day's labor and delivery team. The team was concerned that the patient had poor dating criteria for post-dates induction and decided to perform an ultrasound examination. The exam showed normal placenta and fluid, and a cephalic singleton with symmetric measurements and estimated fetal weight of 2200 gm, consistent with an estimated gestational age 33 +/- 3 weeks.

The team stopped the induction at this point and observed the patient until her contractions subsided. The next day her cervical examination had regressed to 1 cm dilatation. The team planned to offer amniocentesis or continued twice weekly testing for 3 weeks with follow-up ultrasound for serial growth if undelivered in 3 weeks.

Given the patient's late entry to care and difficulty keeping ultrasound appointments, the physicians were concerned that she might not return twice weekly for fetal surveillance. An amniocentesis showing fetal lung maturity would permit induction of labor without the risks of loss to follow-up for a possible post-dates or growth-restricted pregnancy. The patient complied with fetal surveillance and delivered a healthy baby boy 3 weeks later.

Which End Is Which?

The Case

A 39-year-old woman with chronic peri-anal fistulas and infected anal sinuses underwent laparoscopic diverting colostomy to divert her fecal stream and allow the perineum and anal lesions to heal. During the surgery, pneumoperitoneum was established and the "floppy descending" colon was identified, mobilized, and divided. The "proximal" end was brought up to skin and sutured, and the distal end was stapled closed.

After 9 days, the failure of gas or stool to appear in the colostomy bag prompted an abdominal CT scan, which demonstrated large bowel obstruction. On return to the OR for laparotomy, it became apparent that the diversion had involved the transverse colon rather than the descending colon. In addition, the distal portion of the bowel had been brought up to the skin as the colostomy, while the proximal end had been stapled shut. This produced a complete bowel obstruction. Surgeons corrected the orientation and performed a new colostomy. After the second operation, the patient's perianal fistulae and infected anal sinuses improved as initially intended.

Another Fall

Case & Commentary: Part 1

A 42-year-old man with alcoholic cirrhosis, coagulopathy, thrombocytopenia, and a history of subdural hematomas (Figure 1) from falls was admitted with new bilateral subdural hematomas. The neurosurgery service drained the hematomas via burr holes. During the first week of hospitalization, the patient received a total of 45 units of fresh frozen plasma to keep his INR below 1.5 in an effort to minimize the chances of expansion of his subdural hematomas. The patient showed continued improvement and was transferred from the ICU to the step-down unit.

Falls are common in older patients, occurring each year in 35%-40% of community-dwelling persons older than 65 years. In hospitalized or institutionalized persons, falls are even more common—some studies suggest that more than 50% of nursing home residents fall annually. Injury rates are

also higher in institutionalized patients, with 10%-25% of falls resulting in serious injury (fracture, laceration, or need for hospital care).(1)

Many risk factors (Table) have been described for falls,(1-4) including mobility impairment, muscle weakness, postural hypotension, visual deficits, cognitive impairment, and use of certain medications (psychotropics, class 1a antiarrhythmics, digoxin, and diuretics). Risk factors can be thought of as being intrinsic (eg, leg weakness, poor balance, cognitive impairment, visual deficit), extrinsic (eg, polypharmacy), or environmental (eg, poor lighting, loose carpets). In one study of hospitalized patients, the presence of two or more risk factors (agitation, urinary frequency, fall as presenting complaint, unstable gait, poor vision) successfully identified a group at high fall risk.(4)

The patient in this case is somewhat atypical because he is young. However, he has one of the most potent risk factors for falls: a history of more than one previous fall, with evidence of injury from the falls. There may be other contributors here as well (eg, intoxication, encephalopathy, weakness, polypharmacy), although we cannot be sure from the history.

Case & Commentary: Part 2

The patient was identified as being a fall risk. The following precautions were taken: Side rails up; Bed in lowest possible position; Call light immediately accessible; Patient told explicitly "Call nurse if you need anything"; Patient placed in area with many nurses nearby; Bed alarm activated. The patient stated he did not want to be restrained, and staff believed him to be competent. The next evening the patient attempted to climb out of bed by squeezing between the bed rails (Figure 2) and fell to the ground.

Various strategies are used for fall prevention in the hospital. Perhaps the most common strategy is the use of restraints, including physical restraints (eg, wrist restraints, vests, bed rails) and chemical restraints (ie, psychotropic medications). At the other end of the spectrum are multifactorial interventions involving comprehensive structured individual assessments, which attempt to identify and modify known risk factors for falls. These multifactorial interventions include such components as education of staff, review and modification of medications (especially psychotropic medications), institution of exercise and balance training, and modification of environmental hazards. Still other strategies, many of which were implemented in this case, rely on specific interventions to prevent falls or mitigate their damage when they occur: bed alarms to notify staff when a patient attempts to get out of bed; moving the patient to a room close to the nursing station; obtaining a sitter for agitated patients who appear to be at high fall risk; and moving the patient's mattress to the floor. The last strategy (moving the mattress to the floor) is one of my favorites, because it is a simple and direct maneuver that

eliminates the risk of serious trauma that might be sustained if an agitated, unstable patient tried to climb out of bed. It is, however, frequently challenging to implement because it is perceived as making tasks more difficult for doctors and nurses (since they have to bend to reach the patient) and as being less clean.

Unfortunately, the evidence to support any particular fall reduction strategy in the hospital is quite weak,(1,5,6) and many interventions can be promoted only on the basis of their face validity. Although multi-component/multifactorial interventions have been shown to work both in the community (7) and in nursing homes,(8) no good randomized controlled trials have yet demonstrated their efficacy in the hospital. The evidence for other more specific interventions is also lacking.

This patient specifically stated that he did not want to be placed in restraints. The use of restraints poses special concerns.(9-16) First, there is the obvious consideration relating to the unwanted, sometimes violent, infringement of individual liberty and autonomy. Developing adequate safeguards to ensure appropriate use of restraints is a major task in hospitals. Second, substantial evidence indicates that restraint use can harm, and occasionally kill, patients.(14-16) Use of physical restraints does not reduce serious injury (9); in fact, the literature suggests that just the reverse is true.(11-13)

Bed rails form an important subcategory of physical restraint. The use of bed rails is ubiquitous, and they are frequently perceived as innocuous mobility aids that do not restrain the patient. However, most experts consider bed rails a form of restraint that can restrict freedom of movement. In fact, patients may injure themselves more seriously by trying to climb over bed rails than by simply getting out of bed (as in this case), and there are case reports of fatal patient entanglements in bed rails.(15)

Coagulopathic patients may represent a patient category in whom special precautions are warranted. However, the presence of coagulopathy alone should not justify restraint use. For this particular coagulopathic patient, several commonsense steps appear to have been taken to reduce the risk of falls (for instance, placing the bed in the lowest possible position). Nonetheless, bed rails were used in spite of the patient's wish not to be restrained. Bed rails should only be used in select instances, such as for the specific purpose of facilitating bed mobility in patients with weakness (eg, after a stroke) who are receiving rehabilitation or in sedated or somnolent patients who are on life-sustaining treatments. Given the information presented, I do not think bed rails should have been used for the patient in this case. Although some nurses or physicians may resist the idea of leaving the rails down in the confused or agitated patient, this case, in which the fall actually occurred while the patient was trying to climb out of bed by

squeezing between the bed rails, demonstrates why this strategy is well worth considering. Each of the other five interventions was entirely appropriate.

Case & Commentary: Part 3

The patient was found on the floor with no sign of injury. He agreed to be placed in a Posey overnight. Two days later, he was transferred to the medical ward. The nurses identified him as being at "very high risk" for falls and thought the patient should be placed in restraints. However, he adamantly refused. The staff again believed the patient to be competent and therefore did not feel they could restrain him against his will. No psychiatric evaluation was requested.

Sidebar: Medicolegal Issues in the Use of Restraints by: Bryan Liang, MD, PhD, JD

The use of restraints in hospitals is controversial. Most accreditation and advocacy groups strongly recommend use of other means if at all possible.(1,2) Although generally used to prevent injury from falls, restraints may also cause injury. From a legal perspective, physical restraints that result in injury may lead to a lawsuit adjudicated under the *standard medical malpractice negligence rule*. This rule generally requires a patient-plaintiff to show a breach of the relevant standard of care. If the standard (as usually determined by expert testimony) is that the patient, when taking into account all relevant clinical and sociomedical circumstances, was a risk to himself or others in the hospital, restraints may be deemed justified.

Alternatively, the patient's attorney may choose to have the suit heard under a *general negligence* rule. This latter circumstance would not require a professional standard of care to define what is acceptable. Rather it would rely on a layperson's determination of whether use of restraints in the specific circumstance was "reasonable." Since use of restraints is a very emotional issue and would be evaluated in hindsight, providers may risk significant liability under this kind of general negligence suit.

Restraint use against a patient's wishes is generally justified only when a professional assessment of the patient indicates that he or she is likely a risk to him or herself and/or others.(3,4) Such a determination is often linked to an assessment of mental competence, and a relevant consultation (usually by a psychiatrist) should be obtained for this evaluation. However, a patient who is a risk to him or herself or others does not need to be deemed permanently incompetent to be restrained; even temporary incompetence (for example, due to pharmacotherapy or alcohol abuse) may justify involuntary restraint. It is critical that all providers document findings regarding competency and recommendations for restraints carefully in the chart. Failure to do so may

result in litigation for false imprisonment, a very serious cause of action, which could subject the provider to liability, including an award of punitive damages. Of course, providers who negligently ignore a patient's repeat falls might also be subject to liability. Thus, careful risk assessment and competency evaluation are imperative in cases where involuntary restraints are considered.

Overall, in this case, it appears that the patient was competent, and thus providers would not likely be able to override his wishes regarding restraints. However, it would be prudent for providers to obtain a psychiatric consultation to test this conclusion, particularly because of the high risk of repeat falls that were identified by various providers during the patient's care.

When "Psychiatric" Symptoms Are Not

The Case

A 70-year-old man without documented past psychiatric history was placed on an involuntary hold as a danger to others and for grave disability because of his belief that his neighbors were shocking him with low-voltage electricity.

The patient had been seen for many years through a local HMO and his records indicated no psychiatric or medical disorders other than a remote GI bleed. A friend of the patient's reported the patient had believed for the past 5 to 7 years that the "shockers" had been after him. In the 2 weeks prior to hospitalization, the patient reported they had somehow "upped the current."

At a local ER, the patient had normal labs and physical examination, with a confirming non-focal neurologic exam on admission to the psychiatric inpatient unit. The patient used a walker for ambulation "because of pain." He was diagnosed as Psychosis NOS (not otherwise specified) with a note in the plan to defer starting anti-psychotic medications and rule out medical etiologies for his acute symptoms.

The treating team began low dose haloperidol. On the first day of hospitalization, the patient complained that he couldn't move because he was shocked by something in his room. Although he felt paralyzed, he was able to lift both legs off the bed and move his toes. On day 2, he was incontinent of urine. He was placed on an extended involuntary hold on day 3. By day 4, he reported continued difficulty moving, continued incontinence of urine, decreased sensation below the waist, and constipation.

Neurology was then consulted. They found his history and findings on exam to be concerning for spinal cord pathology of advanced severity. They ordered an MRI of the spine, which demonstrated an infiltrating mass between T8 and T10

with well-preserved disc space, thought most likely to be either lymphoma or metastasis. Brain metastases were also present.

The patient was transferred to the inpatient medical unit for CT-guided biopsy and other indicated procedures.

The consensus was that the patient's prognosis was not affected by the several-day delay. His neurological status improved after radiation treatment for his cord compression, but the mistake could have resulted in permanent loss of neurological function.

Flying Object Hits MRI

The Case

A child was brought to the Magnetic Resonance Imaging (MRI) room for a brain scan. Accompanied by an anesthesiologist, the child was receiving sedation for the MRI via an infusion pump with a long IV tube. The anesthesiologist was aware that the pump needed to be kept away from the magnet. The pump was placed 10 to 15 feet away from the MRI magnet on top of a garbage can, as is the practice at the hospital—no bracket is used to secure the pump.

When the scan was completed and the patient was to be wheeled out from inside the scanner, the anesthesiologist brought the pump to the foot of the bed to secure it to a bracket there. However, the child made an unusual noise, which caused the anesthesiologist to turn around suddenly. As he did so, the pump flew out of his hand and hit the magnet, which is always on. The impact damaged the pump, but the child was unharmed.

Root Cause Analysis later revealed the following background information: Metal items are kept outside of the MRI room, but an exception is made for infusion pumps, which are allowed inside the room at a safe distance from the MRI magnet. However, at this hospital, no bracket is used to secure the pump, and no markings are present on the floor or elsewhere to indicate what is considered a safe distance. Following this event, the hospital has committed to purchasing MRI-safe pumps and installing brackets in MRI rooms to secure the pumps. Additional staff education and posted warnings have also been put in place. Other solutions such as using metal detectors and double-checking people before they enter the MRI room are also being considered.

Procedural Mishap: Learning Curve?

The Case

A 28-year-old multiparous obese female presented for laparoscopic tubal ligation. The patient had undesired fertility and was sure of her decision for permanent sterilization. She consented to a laparoscopy.

During the procedure, poor visualization and inadequate gas expansion led the team to believe that they had not yet entered the peritoneal cavity. Replacement of the trocar and laparoscope were performed. The anesthesiologist then noted a rapid decrease in the patient's blood pressure and increasing tachycardia, indicating a possible vascular injury. Conversion to open laparotomy revealed bleeding due to a laceration of the right common iliac artery. Pressure was applied and vascular surgery was consulted. End-to-end anastomosis of the artery was successfully performed, followed by the planned bilateral tubal ligation. The patient had an uncomplicated postoperative course. Serial Dopplers of distal arterial pulses were normal, and the patient was discharged home in stable condition.

The main operator was a trainee, supervised by a senior attending. The trainee was relatively inexperienced in the procedure. The patient was obese, which added somewhat to the complexity, but nevertheless the procedure was considered routine and the complication unexpected.

Unexplained Apnea Under Anesthesia

Case & Commentary: Part 1

A 15-year-old boy underwent elective right knee arthroscopy and debridement under general anesthesia with a laryngeal mask airway (LMA). He was otherwise healthy with no allergies to medications. After uneventful induction of anesthesia, the surgeons requested antibiotic prophylaxis with cefazolin 1 gram, which the anesthesiology team administered. Just before the surgical incision was made, 50 mcg of Fentanyl was administered. About 2 minutes later, spontaneous respirations slowed, and the patient became apneic. The surgeon and anesthesiologist assumed the patient's apnea was due to opiate sensitivity and assisted ventilation by hand for 30 minutes. However, despite a rise in the end-tidal CO2 to 70mm Hg, spontaneous respirations did not return.

Apnea during anesthesia has several etiologies, including anesthetic agents themselves, as well as opiates, barbiturates, or benzodiazepines, and hypocarbia-induced respiratory depression. Prolonged apnea occurs more often in hyperventilated patients; neonates; elderly patients; patients with compromised renal, pulmonary, or hepatic function; hypothermic and acidotic patients; patients receiving neuromuscular blockade, aminoglycosides, or intravenous magnesium; and patients with neurological impairment or injury.

Assuming this patient is healthy, normothermic, and not acidotic or hypocarbic, and assuming he did not receive neuroaxial anesthetic blockade (such as spinal or epidural regional anesthesia), I would be concerned that he received an unplanned drug due to a syringe or an ampoule swap.(Table 1) While maintaining cardiovascular and respiratory functions, clinicians should attempt to ascertain whether a wrong drug was administered, and if so, which drug.(Table 2) (1) The most common drugs that may lead to apnea include muscle relaxants or highly potent opiates (such as Sufentanil, which is ten times as potent as fentanyl). Alternatively, the patient may have a previously unrecognized metabolic disorder such as a neuromuscular disease (ie, myasthenia gravis) or a structural abnormality (ie, stroke or embolism) that needs to be evaluated.

Treatment of medication-induced respiratory depression varies by cause. When respiration is depressed by opiates, as evidenced by miotic, unresponsive pupils, naloxone (Narcan) in 0.04 mg increments may be titrated to reverse the condition. In the case of persistent peripheral muscle blockade, typically due to residual muscle relaxants, reversal with neostigmine is initiated. Other interventions include discontinuation of anesthetics, determination of arterial blood gases, and appropriate adjustment of ventilation.(Table 3)

Case & Commentary: Part 2

Because the apneic episode lasted longer than 30 minutes, the anesthesia team began to question their initial assumption that the apnea was due to opiate sensitivity. They had obtained the cefazolin from the medication drawer of the anesthesia cart. The anesthesia team examined the drawer and found vials of cefazolin and vecuronium (a long-acting paralytic agent) in adjacent medication slots. The vials were of the same size and shape, with similar red plastic caps.(Figure 1) The team realized that the patient had received vecuronium 10 mg, not cefazolin 1 g, and that the observed apnea was therefore due to unrecognized muscle relaxation.

There is no accurate measure of the morbidity and mortality associated with anesthesia. It has been estimated that between 2000 and 10,000 patients die each year from causes at least partially related to anesthesia, but those estimates are based on circumstantial data and include all patients regardless of age or physical status.(2) A recent study in the United Kingdom found that only 1 patient in 185,000 died solely as result of anesthesia, although 1 in 1351 deaths was in part related to anesthesia.(3) An estimated 44,000-98,000 Americans die in hospitals each year as a result of preventable medical errors.(4) Medication errors were the number one cause of adverse and preventable patient events, leading to more than 7000 deaths annually.(4)

The prevalence of medication errors in the operating room is not accurately known, although it is probably similar to that of medication errors in the hospital. Bates and colleagues have shown that 6.5% of admitted patients suffered an adverse drug event.(5) Of these events, 28% were due to errors, and an additional 5.5% involved near misses caught due to interception of the error. In the Harvard Medical Practice Study, adverse drug events accounted for 19.4% of all disabling adverse events, 45% of those events were caused by errors.(6) In a large insurer's study, injuries due to drugs were the most frequent cause of procedure-related malpractice claims.(7)

Wrong medication administration in the operating room is due to failure to label syringes, incorrect matching of labels on syringes and drug ampoules, failure to read the label on the vial/ampoule, misuse of decimal points and zeroes, and inappropriate abbreviations. What happened to this patient illustrates an example of faulty drug identity checking, where two drugs were packaged in similar vials, so that one was easily mistaken for the other. Poor system design also makes errors difficult to intercept before injury occurs. Leape and colleagues discovered that failures at the system level were the real culprits in more than three-fourths of adverse drug events.(8) Reason and colleagues suggested that some complex healthcare systems are more vulnerable and therefore more likely to experience adverse events.(9)

Documenting errors at the administration stage is difficult, because it requires direct observations and reliable, robust near-miss and adverse-event reporting systems. Currie and colleagues found 144 incidents related to drugs, of which 58 were related to syringe or drug swaps,(10) among the first 2000 incidents of the Australian Incident Monitoring System. Of those 58 events, 71% involved muscle relaxants. Implementing a red syringe color change for all Succinylcholine drug administration in Australia has helped to reduce drug and syringe swap by 70%.(11) A large, retrospective study of anesthesiologists' self-reported incidents found that of a total of 1089 incidents, 71 were related to either syringe or drug ampoule swap (7%).(12) Leape and colleagues found that 40 of 334 errors (12%) at the stage of drug ordering and delivery were due to imperfect dose and identify checking.(8) Studies in intensive care units have produced similar results.(13)

Administrative medication errors in the operating room and intensive care unit are believed to be more common in unfamiliar settings, when drug packaging or ampoules have changed, when similarly appearing ampoules are stored close together in the medication carts, when syringes are prepared by other personnel, when hand written labels are used, and when lighting conditions are poor.(14) There is an exponential relationship between the number of drugs administered to a patient and the prevalence of adverse drug events.(15)

Although there is no excuse for failing to read medication and syringe labels, the occasional failure to do so represents an expected "slip," more likely to

occur with fatigue, distraction, or other causes of momentary lapses in concentration and failures in automatic behaviors.(16,17,20) Not until recently did the pharmaceutical industry realize the importance of packaging medications to easily facilitate rapid identification of and discrimination between potent drugs used in operating rooms. For years muscle relaxants such as pancuronium vials were very similar to those of heparin. Some manufacturers continue to package ephedrine in ampoules similar to those of oxytocin and epinephrine. This problem also occurs with different doses of the same drug--the vials for at least three concentrations of atropine sulfate from one manufacturer are similar. This results in inadvertent over- and under-dosing.

Any medication drawn into a syringe for later use should be labeled immediately. Unlabeled and incorrectly labeled syringes invite errors in drug administration and dosing and should be discarded. Routine use of approved, commercial color-coded labels may reduce these errors. The labels should conform to the standards of the American Society for Testing and Materials (ASTM).(18)

A cluttered and disorganized workspace also predisposes to medication errors and searches that can delay administration of emergency medications. All anesthesia and resuscitation medication carts should be standardized,(Figure 2) by applying a systematic method for stocking new and discarding outdated medications.

Case & Commentary: Part 3

Hand ventilation was continued to achieve normocapnia until the muscle relaxant had dissipated and neostigmine could be administered. After reversal of muscle relaxation, apnea resolved, anesthesia was discontinued, and the patient was transported safely to the post-operative care unit, where he recovered fully and was discharged.

To understand the causes of errors, we must examine what happened, what was the root cause, and what were the underlying system failures.(19) In a systems analysis, people are viewed as an important safety resource, not only a source of errors. Designing robust transparent systems, with built in feedback control strategies is important given human flexibility and fallibility. This was a case of unintentional administration of a paralytic agent in place of an antibiotic due to similar packaging. System checks that could be implemented here to avoid inadvertent drug swaps include color-coded labeling and reorganization of the anesthesia cart.(Table 4) Training all healthcare professions in the Six Right's—patient, drug, dose, route, time, concentration—is critical to effective and safe medication administration. Recognizing environmental factors that predispose and distract clinicians is

paramount. These include: noise, interruptions, fatigue and lack of adequate rest, poor lighting, and poor information systems.

Barcoding point-of-care systems (BPOC) are the main technology interventions to prevent medical and blood transfusion errors. The Institute of Medicine report noted that barcoding “is an effective remedy” for medication errors, “a simple way to ensure that the identity and dose of the drug are as prescribed, that it is being given to the right patient, and that all of the steps in the dispensing and administration processes are checked for timeliness and accuracy.” BPOC uses bedside computers that interact with a radio wave-controlled wireless communication system. Changes in medications and other patient information are instantly communicated from hospital information systems to the bedside unit, notifying nurses of changes. BPOC systems enable managers to monitor the medications given to patients and help hospitals identify opportunities for improvements in their medication-administration procedures.

Whenever medications are administered, robust identification systems must be present to avoid inadvertent wrong drug administration.

Patient Mix-Up

The Case

Joe Smith [not his real name], a 42-year-old man with nausea and vomiting for 4 days, was on the general medical service at an academic medical center. Overnight, another man with the last name Smith (Raymond Smith [not his real name]) was admitted to the same room. Usually, this coincidence would have been prevented, but the hospital had a bed shortage. Moreover, the admission occurred at 6:30AM, around the time the nursing shift changed, so that the outgoing staff did not notice that this patient was being placed in a room with another Mr. Smith.

Raymond Smith is a 60-year-old man admitted for treatment of alcohol withdrawal. He was scheduled to receive a dose of IV haloperidol at 7AM. The nurse retrieved the pre-filled syringe from the correct Mr. Smith's medication drawer, but confused the two patients when she entered the room. She was about to administer the haloperidol to the wrong Mr. Smith, but the medical student caring for him was pre-rounding and asked the nurse what medication Joe Smith was about to receive. When the student informed the nurse that the team had not ordered any haloperidol for this patient, they checked the medication administration record (MAR) together and recognized the error. The haloperidol was given to the right Mr. Smith, and one Mr. Smith was moved to another room, to reduce the chance of another such error.