REGIONAL ANESTHESIA AND TRAUMA

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Many anesthesiologists do not even consider regional anesthesia a logical alternative when caring for trauma patients and for many trauma victims this is the correct decision. The beneficial effects of regional anesthesia with its ease of administration, rapid onset, minimal requirements for equipment and medication, and ability to have the patient remain awake is ideal for selected patients in some trauma situations. Although the intubated, multiply-injured trauma victim with a flail chest, upper abdominal wounds, and head injury is not the appropriate patient for regional anesthesia, patients with some lower abdominal, pelvic and extremity injuries have undergone surgical repair under regional anesthesia. Choice of anesthesia in the trauma patient must take neurologic, respiratory, cardiac, hemodynamic stability, and ongoing blood loss into consideration.[6, 13, 14]

HISTORY OF REGIONAL ANESTHESIA IN WAR ZONES

Although initial reports concerning the use of regional anesthesia in war zones were disappointing, more recent data have been encouraging.[13, 14] Physicians who were "forced" to use regional anesthetic techniques when equipment for general anesthesia was scarce or unavailable have adapted its use successfully.[8, 9, 13] In a report on 1311 operations performed under epidural anesthesia during the Vietnam conflict, Bich reported good results while maintaining full consciousness perioperatively avoiding the need for artificial airway support and venti-

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lation.[8] Procedures were not limited to the lower extremities. Neurologic status was easy to evaluate. Combined anesthetic techniques, epidural block for lower extremity surgery, and a brachial plexus block for the arm were utilized for cases of transposition of pedunculated grafts from the forearm to the leg. This enabled the patient to be placed in a sitting position, facilitating surgery and avoiding graft disruption at the conclusion of the procedure. Bich summarized his experience with epidural anesthesia:

> "In the present situation in Vietnam with lack of staff, insufficient equipment for anesthesia, and scant amounts of pharmacological agents, epidural anesthesia was found to be the method of choice for operations on the lower extremities, lower abdomen and back, regardless of the type of operation."[8]

Patients with serious land mine, shell, and bullet injuries to the perineum, abdomen, and lower extremities have successfully been given regional anesthesia. In a study performed in a field hospital along the Thai-Cambodian border, Bion reported the results of spinal anesthesia performed on 29 severely injured patients.[9] Eleven patients had systolic blood pressures less than 90 mm Hg on arrival (mean systolic of 47 mm Hg). After stabilization and fluid administration, the patients were placed with the more severely injured side up and spinal anesthesia was administered with 3 mL of isobaric bupivacaine 0.5% with anesthesia commencing at 1 minute and complete at 2 minutes. There was no significant difference in the drop in blood pressure following spinal anesthesia between patients admitted to the field hospital in a hypotensive state and those normotensive prior to fluid resuscitation (Fig. 1). Only four patients were noted to become hypotensive after the onset of spinal anesthesia: one in the nonshock group and three in the shock group (Table 1). Two patients had severe continued bleeding, a third with a spinal level at T4 and the one nonshock patient who became hypotensive was short in stature. This patient had the same hypotensive episode after receiving a second spinal even though less bupivacaine

Table 1. HYPOTENSION FOLLOWING SPINAL ANESTHESIA, t_0 AFTER INITIAL RESUSCITATION; t_2, t_5, t_{10} MINUTES AFTER SPINAL ANESTHESIA

From Bion JF: Isobaric bupivacaine for spinal anaesthesia in acute war injuries. Anaesthesia 39:554–559, 1984; with permission.

Figure 1. Systolic arterial blood pressures on arrival, after resuscitation, and after spinal anesthesia. A_0 = after initial resuscitation; A_2, A_5, A_{10} = minutes after spinal anesthesia; circles indicate shocked on arrival; triangles indicate not shocked on arrival. (*From* Bion JF: Isobaric bupivacaine for spinal anesthesia in acute war injuries. Anesthesia 39:556, 1984; with permission.)

was utilized. Hypotension was appropriately treated and did not result in any significant side effects. There was a rapid onset of pain relief as well as adequate operating analgesia. Bion believed that the use of the isobaric bupivacaine helped to avoid a high spinal level in the majority of cases.[9]

RISKS AND BENEFITS OF REGIONAL ANESTHESIA

Although wartime situations may require the use of regional anesthesia in unusual circumstances, the risks and benefits of the technique must be considered. The risks of regional anesthesia in trauma patients include the following:[13, 14]

- Hypotension
- Hemodynamic changes in a patient with injuries who may be unable to compensate
- Intravascular injection

- Pneumothorax
- Hemidiaphragmatic paralysis (from interscalene block)
- Horner's syndrome (interfering with neurologic evaluation)
- Seizure
- Unsecured airway in trauma patient
- Masking of compartment syndrome

Although general anesthesia allows controlled ventilation with high inspired oxygen concentrations, patients receiving regional anesthesia must breathe spontaneously. These patients must be able to cooperate, maintain an adequate airway, and breathe adequately without mechanical support.[13, 14]

Hypotension, with the onset of sympathetic blockade, can be disastrous in the hypovolemic, non–fluid-resuscitated trauma patient who continues to bleed. Even in the trauma patient who has been fluid-resuscitated and appears stable, sympathetic blockade may unmask previously unrecognized injuries. If persistent hypotension and hypovolemia occur, the patient should be evaluated to determine the presence of occult chest, intrathoracic, intra-abdominal, pelvic, or extremity injuries.[13, 14]

Epidural and spinal anesthesia should be used with caution in patients with chest trauma. Cardiopulmonary compromise secondary to cardiothoracic trauma may preclude effective compensatory mechanisms. In the patient who has suffered chest wall or intrathoracic injury with compromised pulmonary function, a regional anesthetic technique that may result in a pneumothorax or hemidiaphragmatic paralysis, as may be seen with an interscalene block, may have adverse consequences.[37] A patient with thoracic and cardiopulmonary injuries and compromised pulmonary function will need intubation and controlled ventilation and not a regional technique and intravenous sedation.[13, 14] Regional anesthesia with or without intravenous sedation is not indicated in patients with head injuries who need to be intubated and hyperventilated.[13, 14]

Another risk of regional anesthesia is masking a compartment syndrome.[36] In a patient who underwent free fibular grafting from one leg to another, postoperative epidural infusion of local anesthesia apparently masked the pain associated with a compartment syndrome of the donor site.[36] Complications such as intravascular injection resulting in arrhythmia or seizure may not be as well tolerated in the trauma patient as in a healthy surgical patient.

Benefits of Regional Anesthesia

Dow has described the benefits of regional anesthesia, which include the following:[14]

- Supplement or replace general anesthesia
- Reduce sympathetic tone
- Improve local and systemic hemodynamics
- Improve blood supply
- Modify the stress response
- Decrease the incidence of deep vein thrombosis
- Decrease blood loss
- Provide postoperative pain relief after reimplantation
- Provide pain relief

Reduced sympathetic tone, reduction of the stress response, and decreased oxygen consumption are associated with regional anesthesia, and this may be beneficial to the trauma patient. This may lead to decreased oxygen consumption and possibly be beneficial to the patient.[13, 14, 18, 19] Reduction in sympathetic tone can improve both local and systemic hemodynamics.

Epidural and spinal anesthesia has been shown to decrease the incidence of deep vein thrombosis and pulmonary embolism in orthopedic patients.[13, 14, 18, 19] Many reports document the efficacy of regional anesthesia in maintaining adequate blood flow and pain relief in patients who have undergone reimplantation of an amputated digit.[5]

Regional Anesthesia Utilizing a Nerve Stimulator

At the Hospital for Joint Diseases Orthopaedic Institute (HJDOI), we perform regional anesthesia with the use of a nerve stimulator and an insulated needle. With this technique, the needle is positioned in close proximity to the nerve without seeking a paresthesia. Although others seek paresthesias, we avoid this approach to decrease the possibility of nerve damage associated with paresthesias.[34]

The key to success is obtaining a maximal twitch at the lowest milliamperage possible in the nerve distribution supplied by the nerves to be blocked. Administering local anesthesia once this condition has been achieved will result in a very high success rate. The nerve stimulator must have a digital readout so the user can be certain that the current that is delivered can be as low as 0.1 or 0.2 milliamps (mA). Utilizing an insulated needle isolates the current to the distal tip of the needle, ensuring that local anesthesia is administered at the precise location where the twitch is obtained. (Figs. 2 and 3).[6, 25, 29]

Why is obtaining a twitch at the lowest mA possible an appropriate end point prior to injection of local anesthesia? The current necessary to stimulate a nerve decreases according to the inverse square rule: the closer the nerve, the less current required. Therefore, if a very low current is utilized to stimulate the nerve, the needle has to be in very close proximity to the nerve.[25]

Figure 2. Electric current is concentrated at the tip of the insulated needle but is diffuse in the noninsulated needle. (*From* Bernstein RL, Rosenberg AD: Manual of Orthopedic Anesthesia and Related Pain Syndromes. New York, Churchill Livingstone, 1993, p 171; with permission.)

Performing the Block

1. The landmarks are identified and the skin is prepped and draped.
2. A ground electrode (positive lead) is attached to an electrocardiogram (EKG) pad placed on the patient on the opposite extremity of the one to be blocked.
3. The nerve stimulator is set to deliver a current between 1.0 to 2.0 mA at 1 twitch per second (in general the lower current for upper extremity blocks and the higher current for sciatic blocks).
4. A skin wheal is raised and an 18 gauge needle is used to create a small opening for the insulated needle.
5. The negative electrode from the nerve stimulator is attached to the metal hub or connector of the insulated needle and the needle is advanced toward the nerves to be blocked.
6. Observe for muscle twitches in the distribution of the nerves to be blocked.
7. Once twitches are obtained, the needle is advanced or withdrawn slowly while observing the twitch response.

Figure 3. Nerve stimulator set-up. Block needle is attached to negative electode of nerve stimulator, ground to positive terminal. Injection is performed where maximal twitches are obtained at lowest amperage. (*From* Bernstein RL, Rosenberg AD: Manual of Orthopedic Anesthesia and Related Pain Syndromes. New York, Churchill Livingstone, 1993, p 173; with permission.)

8. Twitches are maximized at the lowest mA possible (0.1–0.4 mA range, depending upon specific block).
9. Once maximum twitches are obtained, stabilize the needle, aspirate to check that the needle is not intravascular and then inject 2 mL of local anesthesia. The twitch should be abolished.
10. With intermittent aspiration, the remainder of the local anesthesia is injected.[6]

Observe the patient carefully for signs of local anesthetic toxicity, including perioral numbness, ringing in the ears, seizure activity, or arrhythmia. If a seizure does occur, treat promptly with a short-acting barbiturate and ensure that the patient has an adequate airway.[6, 32]

LOWER EXTREMITY TRAUMA

The Patient with a Fractured Hip

Many recent studies indicate that anesthetic technique (regional or general) is not the critical factor in determining outcome, but other factors such as comorbidity, American Society of Anesthesiologists (ASA) classification, age or sex may have more of an effect on outcome than anesthetic technique.[6, 12, 19, 38, 39]

Mortality rates in geriatric patients after hip fracture range from 14% to 36%.[39] Preexisting medical conditions are associated with increased mortality. Kenzora demonstrated that patients with four or more preexisting medical conditions or comorbidities had significantly higher mortality.[20] White et al were able to demonstrate that higher ASA classification was associated with higher morbidity and mortality in patients with a hip fracture.[39] In their study, patients with an ASA I or ASA II classification had an 8% mortality rate, whereas those classified as ASA III or IV had a 49% mortality rate. When corrected for death rates in patients the same age but without hip fracture, the ASA III or IV patients had a much higher mortality rate.[39]

Studies by Valentin et al and Davis et al demonstrated no significant difference in outcome between spinal or general anesthesia.[12, 38] Although some studies consider the effect of anesthetic technique on long-term mortality, others prefer to study the short-term effect. Recently at HJDOI we studied in-house mortality of hip fracture patients to determine if anesthetic technique or other factors affected short-term outcome. Of 622 patients, in whom 57% received general anesthesia and 43% received spinal anesthesia, there was no increased in-house mortality with spinal or general anesthesia. A higher incidence of postoperative mortality was noted in ASA III and IV patients ($P = 0.002$), those with age greater than or equal to 85, ($P < 0.01$) and men ($P = 0.02$). Table 2 demonstrates the factors associated with increased mortality in hip fracture patients.

Case Presentation

A 51-year-old woman with severe chronic obstructive pulmonary disease fell and fractured her hip. A room air arterial blood gas demonstrated her usual baseline PaO_2 of 50 mm Hg with an oxygen saturation of 88%. The patient was positioned on the operating room table with the fractured side up and given 3 mL isobaric bupivacaine 0.5% with 0.3 mg epinephrine and 0.3 mg preservative-free morphine. The patient tolerated the procedure well.[6]

At the HJDOI, many patients receive spinal anesthesia for repair of a hip fracture using 3 mL of isobaric bupivacaine, 0.5%, with epinephrine. Intrathecal morphine may be added to the spinal anesthetic. Prior to administering spinal anesthesia the patient is evaluated for signs of hypovolemia by evaluating the size of the thigh from bleeding, skin turgor, urine output, intravenous fluid infusion rate, blood pressure,

Table 2. FACTORS ASSOCIATED WITH INCREASED MORTALITY IN HIP FRACTURE PATIENTS

	ASA Classification	Concurrent Medical Problem Comorbidity	Increased Age	Male Sex	Spinal or General	Fracture Type	Dementia
Valentin et al[38] Short-term			√	√	No	Trochanteric	
Long-term	√			√	No		
Davis et al[12] Short-term	√	√	√		No		
Long-term	√	√	√		No		√
Kenzora et al[20] Long-term		√ (4 or more)	√ With intertrochanteric fracture				
White et al[39] Long-term	√		↓	√			
Rosenberg Short-term	√		√	√	No		

and heart rate. This determination is especially important in patients with a history of congestive heart failure who as a result of the fracture may have lost blood into the hip region and as a result of medical intervention may have been diuresed until their intravascular volume is low. In these patients, sympathetic blockade and its associated peripheral vasodilation may result in a hypotensive patient in need of fluid resuscitation. In patients with adequate intravascular volume, a spinal anesthetic may cause hypotension necessitating infusion of vasopressors such as neosynephrine to maintain an adequate blood pressure. Although fluid infusion might be considered a more conservative approach than starting a vasopressor infusion, the patient who is vasodilated from sympathetic blockade and maintained with a vasopressor perioperatively will not suffer from fluid overload and pulmonary edema as the spinal anesthetic recedes and vascular tone returns.[6]

Although we prefer to use isobaric bupivacaine for spinal anesthesia, others use hyperbaric or even hypobaric medications. Sidi et al utilized hypobaric spinal anesthesia with 0.1% tetracaine to a dose of 0.2 mg/kg with or without epinephrine.[35] This technique was used in 40 patients averaging 77 years of age. The hypobaric spinal technique allowed the patient to be positioned with the injured extremity up. In Sidi's study, only one patient had inadequate analgesia.[35] Although 35% of the patients had blood pressures that diminished by more than 30%, the decrease was easily treated with vasopressors; however, the hypobaric spinal technique should not be employed if the procedure is going to last more than 2 hours because anesthesia will become inadequate.[35]

Lumbar Plexus Block for Repair of Fractured Hips

Case Presentation

An 80-year-old woman with chronic obstructive pulmonary disease (COPD) and moderate to severe aortic stenosis presented for repair of a nondisplaced subcapital fracture of the hip. The patient was placed with the fractured side up, avoiding pressure on the fracture site and possible displacement. Landmarks were identified, and the patient was given a lumbar plexus block utilizing a nerve stimulator and insulated needle (Fig. 4).

The lumbar plexus block is useful in patients in whom maintenance of stable hemodynamics is critical. The sympathetic blockade, vasodilation, and afterload reduction that occur with spinal anesthesia are avoided. This may be especially important in the case just described in a patient with aortic stenosis.

Chayen utilized the lumbar plexus or psoas compartment block in 100 patients undergoing repair of a hip fracture, amputation, femoral plating, or removal of femoral nails.[11] Patients were placed in the lateral position with the fracture side up. The anesthetic technique is based on the location of the lumbar plexus which arises from the L2 to L4 nerve roots.[6, 11] The lumbar plexus is located between the psoas and the quadratus lumborum muscles and forms the femoral nerve, the obturator nerve, and the lateral femoral cutaneous nerve. In Chayen's technique, a line is drawn across the iliac crests. At a point 3 cm caudad and 5 cm lateral to the midline a 15 cm, 20 gauge needle is advanced until the L5 transverse process is encountered. Utilizing a "loss of resistance" technique, the needle is then redirected in a cephalad direction and advanced until a loss of resistance is noted as the needle is passed through the quadratus lumborum muscle and into the psoas compartment. The depth of the compartment is approximately 12 cm. Utilizing this technique in 100 patients, Chayen had a 90% success rate.[11] Winnie utilized a nerve stimulator and an insulated needle placed at the intersection of a line between the iliac crest and a second perpendicular line drawn through the posterior superior iliac spines to perform lumbar plexus blocks.[41] Our preference is to utilize a point that is 5 cm lateral to the L3 spinous process.[6] Once the transverse process is encountered the needle is then redirected inferiorly to the transverse process while observing for twitches in the distribution of the nerves supplied by the lumbar plexus. Twitches are usually obtained at a depth of 7 to 10 cm initially at 1.5 to 2 mA but as the current is decreased and maximal twitch response is obtained, twitches can be observed in the 0.2 to 0.3 mA range.[6] Once the twitches are obtained in this range and aspiration is negative, 2 mL of local anesthetics are injected. This is followed by 40 mL of 1.5% lidocaine with epinephrine 1:200,000 with intermittent aspiration.[6] In a slight modification of this technique, the local anesthetic can be administered at more than one level (L3 and L4).

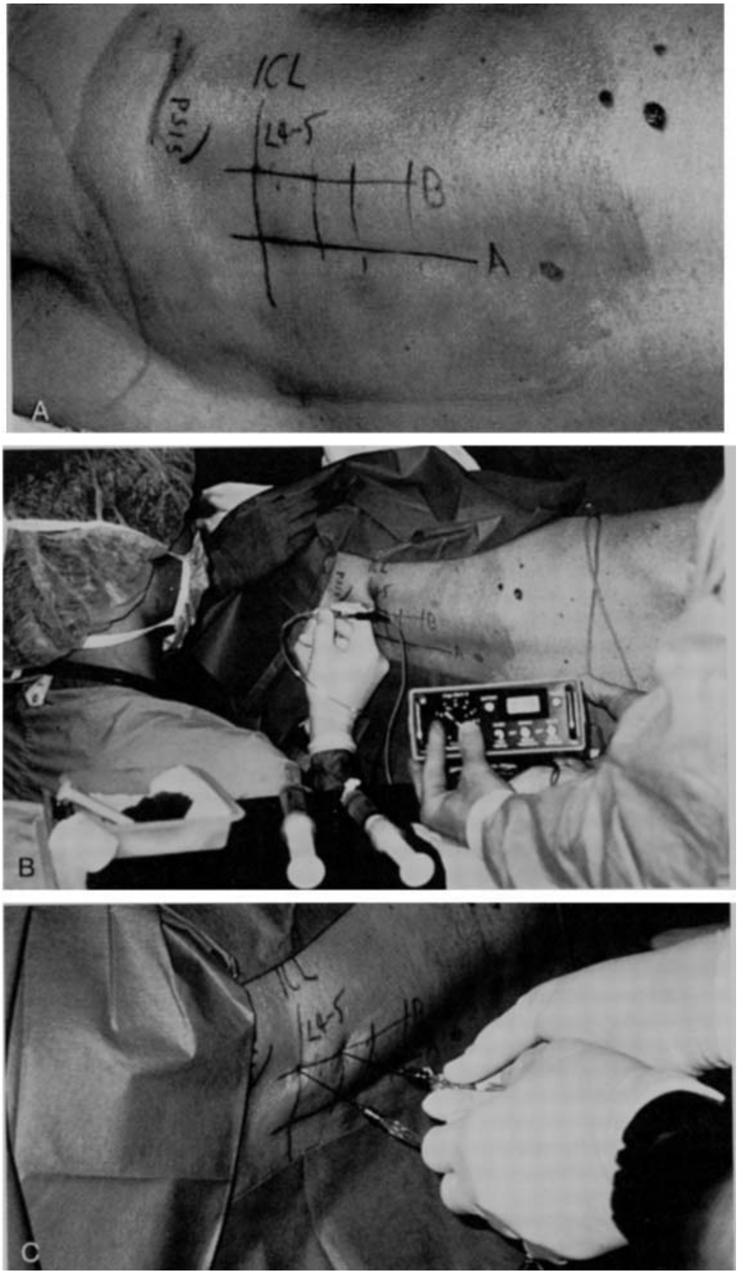

Figure 4. Lumbar plexus block. *A*, Anatomy marked out: PSIS = posterior superior iliac spine; ICL = intercristal line; A = line along spinous process; B = line parallel to line A through PSIS. *B*, Block with nerve stimulater. *C*, Close-up of lumbar plexus.

Individual Nerve Blocks

Individual nerve blocks can be used to provide anesthesia for repair of a fractured hip, especially when Knowles pins are inserted for subcapital fractures. Femoral, lateral femoral cutaneous, and obturator nerve blocks can be used either individually or in combination.

Case Presentation

A 63-year-old man with a history of moderate to severe mitral stenosis, a history of atrial fibrillation, an ejection fraction of 40%, left ventricular dysfunction, and a history of lymphoma treated with chemotherapy presented with a subcapital fracture of the femoral head. The surgeon planned to repair the fracture with Knowles pins. Current medications were digoxin and furosemide. A pulmonary artery catheter, placed preoperatively, demonstrated stable hemodynamics, but an elevated pulmonary artery pressure of 75/35 mm Hg and a systemic pressure of 140/40 mm Hg. A femoral, lateral femoral cutaneous, and obturator nerve block utilizing bupivacaine 0.5% and lidocaine 2% was performed using fentanyl 150 μg and midazolam 1 mg for sedation. The patient tolerated the procedure without any problems.

Howard et al performed combined femoral and lateral femoral cutaneous nerve blocks in 30 patients, average age of 77 years for repair of femoral neck fractures.[17] In addition to the nerve blocks, bupivacaine 0.5% was also utilized at the site of pin insertion. Nerve blocks were supplemented with ketamine and diazepam sedation.[17] Nerve blocks performed for surgical correction can also be utilized for obtaining postoperative pain relief.[16] Hood, in a randomized study of patients with intertrochanteric fractures compared patients receiving general anesthesia with etomidate, N_2O, O_2, isoflurane, alfentanil, and postoperative narcotics with those receiving a 3-in-1 femoral nerve block (femoral, obturator, lateral femoral cutaneous nerves) and a subcostal nerve block. Nerve blocks were performed with an insulated needle utilizing Winnie's inguinal paravascular technique (see later section).[16, 42] Patients receiving nerve blocks had significantly reduced analgesic requirements with 48% requiring no additional analgesia in the first 24 hours.[16]

Femoral Nerve Block

In trauma patients suffering from femoral fractures, it is often very painful to transfer the patient from the hospital bed to the operating room table. Femoral nerve blocks can decrease pain and facilitate patient movement.[6] This technique had been used in emergency wards to decrease the incidence of pain associated with femoral shaft fractures. In a study of McGlone, femoral nerve blocks utilizing 1% lidocaine with 1:200,000 epinephrine or 0.5% bupivacaine were effective in providing adequate pain relief.[13, 23] Some physicians involved in in-field trauma management employ femoral nerve blocks to diminish pain during transport.

The femoral nerve is located lateral to the femoral artery below the inguinal ligament. A skin wheal is raised lateral to the pulsations of the femoral artery at a point 1 inch below the inguinal ligament. The nerve stimulator is set at 1 to 1.5 mA and an insulated needle is passed through the skin wheal. The femoral nerve is superficial and located approximately 1 cm below the skin. When the femoral nerve is stimulated, twitches are noted on the anterior aspect of the thigh. Maximal twitches at 0.1 to 0.2 mA are sought. After aspiration, 2 mL of a local anesthetic solution are injected and the remaining 10 mL are subsequently injected with intermittent aspiration. If a 3-in-1 block (inguinal paravascular block) is performed instead of having the needle perpendicular to the skin the needle is directed in the cephalad direction until twitches are obtained at 0.1 to 0.2 mA. Distal pressure is utilized to maximize proximal flow of local anesthetic. This distal pressure should be applied prior to obtaining the maximal twitch response so that anatomic alterations do not occur once the best twitch is obtained[6] (Fig. 5).

Figure 5. Inguinal paravascular block. Needle is inserted as in femoral nerve block. Digital pressure is applied distal to needle insertion while performing injection. (*From* Bernstein RL, Rosenberg AD: Manual of Orthopedic Anesthesia and Related Pain Syndromes. New York, Churchill Livingstone, 1993, p 209; with permission.)

Femoral Sciatic Nerve Blocks

Case Presentation

In August 1994, a 19-year-old asthmatic man suffered a temporary loss of consciousness and an injury to his right knee during a motorcycle accident. Although a CT scan was negative, the patient came to our hospital because of persistent neck pain. A nondisplaced odontoid fracture was diagnosed on MR imaging, and the patient was placed in a halo vest. A knee arthroscopy was scheduled. The presence of the halo with its jacket that extended to the lower back made spinal anesthesia difficult and general anesthesia would have required an awake fiberoptic intubation. Femoral, lateral femoral cutaneous, and sciatic nerve blocks were performed with 2% chloroprocaine. A tibial plateau fracture was diagnosed during arthroscopy (Fig. 6).

Femoral-sciatic blocks can be very effective for surgical procedures as well as to provide pain relief for trauma patients. They can be useful for both diagnostic and surgical intervention. Rooks and Fleming successfully utilized femoral-sciatic nerve blocks for evaluation of acute knee injuries.[30] Desai et al have utilized femoral-sciatic block both diagnostically and therapeutically at the R Adams Cowley Shock Trauma Center.[13] At HJDOI we also block the lateral femoral cutaneous nerve to anesthetize the lateral portion of the thigh after blocking the femoral and sciatic nerves.

Sciatic Nerve Blocks

With the hip and knee flexed to 90 degrees, a line is drawn from the ischial tuberosity to the greater trochanter. Slightly medial to the

Figure 6. Sciatic block.

midpoint of this line an insulated needle is passed perpendicular to the skin and parallel to the table (Fig. 7). The goal is to obtain a twitch response in the muscles of the lower leg innervated by the sciatic nerve. As the needle is advanced, while stimulating at 1.5 to 2.0 mA, twitches will be noted in the gluteal muscles. These are not the twitches of sciatic nerve origin. The needle is advanced further until twitches are observed below the knee. After maximal twitch is obtained at 0.1 to 0.4 mA and after aspiration, 2 mL of local anesthetic are injected. Twitch response should be abolished after which the remainder of the local anesthetic can be injected with intermittent aspiration.[6, 27]

Anterior Approach to the Sciatic Nerve

In situations where trauma, traction, or other conditions make it difficult to move or flex the lower extremity, an anterior approach to the sciatic nerve can be used[4, 6] (Fig. 8). An insulated needle and nerve stimulator can be used for this technique. A line is drawn from the anterior superior iliac spine to the pubic tubercle. The line is divided

Figure 7. Supine-approach sciatic nerve block. Needle is inserted between ischial tuberosity and greater trochanter and advanced. Needle is kept parallel to table. (*From* Bernstein RL, Rosenberg AD: Manual of Orthopedic Anesthesia and Related Pain Syndromes. New York, Churchill Livingstone, 1993, p 213; with permission.)

Figure 8. Landmarks for anterior approach to the sciatic nerve. (*From* Beck GP: Anterior approach to sciatic nerve block. Anesthesiology 24:222, 1963; with permission.)

into thirds. A second line is drawn that is parallel to the first and passes through the greater trochanter. A perpendicular is then dropped from the junction of the medial and middle thirds of the first line to the second line. At this point a needle is passed perpendicular to the skin and directed to touch the lesser trochanter. When this occurs, redirect the needle in a more medial direction. Obtain a twitch response at the lowest mA possible, aspirate, and inject 2 mL of local anesthetic. If the twitch is abolished, inject the remainder of the local anesthetic with intermittent aspiration.[4, 6]

Regional Anesthesia for Upper Extremity Trauma

Regional anesthesia for upper extremity trauma can be used for operative repair, prolonged pain relief, and to help maintain good blood flow after reimplantation. Frequently an anesthetic can be administered that provides both intraoperative anesthesia and postoperative pain relief. Based on specific conditions, a single injection, an intermittent bolus technique, or a continuous infusion can be employed to provide perioperative anesthesia and postoperative pain relief.[5, 6, 14, 21, 31, 33]

An interscalene, infraclavicular, or an axillary block can be utilized to anesthetize the upper extremity. Because the choice of block affects which nerves of the brachial plexus are anesthetized, it is important to choose the block that will most frequently anesthetize the area of surgery. For example, ulnar nerve distribution is usually spared in interscalene blocks, and the thumb is not well anesthetized after axillary block. Another concern with upper extremity blocks is sparing of the musculocutaneous nerve, which can occur after axillary blocks because the musculocutaneous nerve is in the substance of the coracobrachialis muscle at this level. A block that spares the musculocutaneous nerve can lead to surgical pain.

Indwelling catheters can help provide postoperative pain relief and improved blood supply for patients requiring reimplantation surgery. In a study of 50 patients undergoing reimplantation, Matsuda et al were able to obtain adequate analgesia in 94% of patients using either an indwelling axillary or supraclavicular catheter.[21] In the supraclavicular region the catheter was passed through a needle once a paresthesia was obtained. One patient who received a supraclavicular nerve block suffered a pneumothorax. In the axillary region 2 Teflon catheters were passed into the neurovascular sheath. Local anesthetic consisted of 1% lidocaine or 0.5% bupivacaine. The interval between injections was approximately 3 hours.[21]

Rosenblatt et al utilized a continuous axillary block to provide perioperative analgesia in a 15-year-old patient who amputated his index finger and lacerated multiple tendons in a table saw accident. Utilizing the nerve stimulator technique, a 5-cm Teflon-coated intravenous catheter over a spinal needle was placed into the neurovascular sheath at the level of the pectoral fold and the axillary artery. The patient received 20 mL bupivacaine 0.75% and 2-chloroprocaine 3% intraoperatively and was started on a continuous infusion of bupivacaine 0.25% 10 mL/hr in the postoperative period. The patient tolerated the procedure well and his postoperative course was eased by the pain relief he obtained.[31] Berger et al utilized injections of bupivacaine every 6 hours to prevent vascular spasm and improve blood flow to reimplanted digits[5] (Fig. 9).

Selander utilized a disposable intravenous catheter for axillary blocks. He noted that the radial and musculocutaneous nerves may be missed with this technique—the radial nerve because it is deep and the musculocutaneous nerve because it enters the coracobrachialis muscle prior to entering the axilla.[33] An alternate technique utilized by Ang, Lassale, and Goldfarb places a catheter more proximal in the axilla, and 51 of 52 patients received adequate anesthesia with this technique. Ang et al abducted the arm to 75 degrees, externally rotated it, and flexed it at the elbow. At a point 40 mm below the axilla and medial to the biceps, a needle is inserted through the skin at a 20-degree angle directed toward the apex of the axilla and parallel to the median nerve.[3] When advancing the needle and reaching a depth of 5 to 10 mm beneath the skin, a "click" may be felt. Aspiration is performed to ensure that the needle is not in a vessel and then local anesthesia is injected. The needle is then advanced, a guidewire is placed through the needle, the needle removed, and an 80-mm long 18-gauge catheter is placed over the guidewire. Anesthesia is obtained with 20 mL 2% lidocaine and 20 mL 0.5% bupivacaine. Intermittent injections of 20 mL were administered. In seven patients, the catheter remained in place for 6 to 9 days[3] (Fig. 10). Kits are available for placing indwelling catheters utilizing a nerve stimulator.

Figure 9. *A*, Acral pulse curve after replantation of fourth finger before plexus anesthesia. Typical spastic deformation with flattened amplitude, extended pulse curve peak, and raised dicrotism. *B*, Acral pulse curve after plexus anesthesia. Normal pulse curve with increased amplitude and regular dicrotism. The same amplification of the recorder as in *A*. (*From Berger A, Tizian C, Zenz M: Continuous plexus blockade for improved circulation in* microvascular surgery. Ann Plast Surg 14:17, 1985; with permission.)

How to Choose the Proper Block

The block of choice for upper extremity anesthesia is described in Table 3.[6, 28, 40] Interscalene blocks are excellent for procedures performed in the shoulder region. Remember that Horner's syndrome is common with an interscalene block and this may complicate neurologic evaluation of the trauma patient. Axillary blocks are especially good for procedures on the ulnar side of the hand; however, because the musculocutaneous nerve is within the coracobrachialis muscle, this may be missed unless a separate injection is performed.[6, 28, 40]

We perform infraclavicular nerve blocks for procedures below the shoulder because the musculocutaneous nerve and the ulnar nerve are blocked with this technique.

Case Presentation

An 83-year-old female patient sustained an open wrist fracture requiring immediate repair and an injury in which the head of the femur protruded into

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Figure 10. Site for insertion of the needle (*) is located about 40 mm below the pectoralis major muscle (PM), between the biceps (BB) and the triceps muscles (TB), medial to the median nerve (M), which is easily palpable under the skin. (*From* Ang ET, Lassale B, Goldfarb G: Continuous axillary brancial plexus block: A clinical and anatomical study. Anesth Analg 63:681, 1984; with permission.)

the acetabulum requiring reduction. She had eaten 3 hours prior to surgery. The wrist fracture was repaired after an infraclavicular block was performed utilizing 25 mL 2% lidocaine with epinephrine 1:200,000 and 7 mL 0.5% bupivacaine. Femoral and lateral femoral cutaneous nerve blocks were performed to reduce the femur. Both regional techniques were successful and the patient tolerated the procedure well.

Table 3. BLOCK OF CHOICE

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From Rosenberg AD, Albert, Bernstein RL: Regional anesthesia for orthopedic trauma. Problems in Anesthesia 8:3, p 437; with permission.

Infraclavicular Nerve Block

The patient is placed in the supine position with the head turned away from the side to be blocked. A skin wheal is raised 1 inch below the midpoint of the clavicle perpendicular to the plane of the clavicle. The axillary artery is palpated in the axilla. A skin wheal is raised and after creating a small opening with an 18-gauge needle an insulated needle is directed toward the axillary artery at a 45-degree angle (Fig. 11). With the nerve stimulator set at 1.0 to 1.5 mA, the needle is advanced. Initially twitches of the pectoralis muscles are noted, but these are due to direct muscle stimulation. The needle is advanced through the pectoralis muscles until twitches are seen in the distribution of the nerves of the brachial plexus.[6, 26]

Maximal twitches at 0.1 to 0.4 mA are obtained. After aspiration, 2 mL of local anesthetic are injected. After intermittent aspiration the remainder of the 40 mL of local anesthetic is injected. Do not be satisfied with twitches that just occur in the distribution of the musculocutaneous nerve because it is the most superficial nerve in this approach and stimulation of this nerve may be occurring across a fascial plane[6] (Fig. 11). Albert et al have demonstrated that a 99% success rate can be

Figure 11. Infraclavicular brachial plexus block. Operator stands on side opposite one to be blocked. Needle is inserted 1 inch below midpoint of the clavicle at a 45-degree angle and directed toward pulsations of axillary artery. (*From* Bernstein RL, Rosenberg AD: Manual of Orthopedic Anesthesia and Related Pain Syndromes. New York, Churchill Livingstone, 1993, p 185; with permission.)

obtained when performing infraclavicular nerve blocks if a twitch is obtained at 0.1 to 0.4 mA and the twitch is distal to the forearm.[2]

Intravenous Regional Anesthesia

Intravenous regional anesthesia is a popular technique for reducing fractures. Desai et al have reviewed the use of the Bier block in trauma patients, which is a frequently employed technique both in the operating room and in emergency rooms.[13] At the HJDOI we do not add any additional medications such as muscle relaxants and perform all our Bier blocks without epinephrine and without preservatives.[6] McGlone et al utilized 2 mg of atracurium with Bier blocks. Addition of 2 mg of atracurium improved the ease of reduction and the quality of analgesia; however, because atracurium is not metabolized in the ischemic limb, patients did have some difficulty with vision after tourniquet release.

McGlone recommends utilizing atracurium in larger muscular patients in whom it appears that reduction is difficult.[22] Physicians who perform Bier blocks in emergency rooms are concerned with the possible systemic side effects associated with the technique. Therefore, instead of using the usual 3 mg/kg dose of intravenous lidocaine administered in the operating room, Farrell utilized half the usual dose and administered mini-dose Bier blocks to 105 people (ages 2–86) with a 95% success rate.[15]

Although believed not to be as successful in providing adequate analgesia, some physicians utilize hematoma blocks to reduce Colles' fractures.[1] Case found the technique easy and as effective as Bier blocks.[10] Meining et al measured venous plasma lidocaine levels in eight patients who received hematoma blocks for reduction of distal radius fractures. With doses less than 2.5 mg/kg, there was a rapid onset of anesthesia, venous lidocaine levels peaked at 20 to 30 minutes, ranging from 100 to 1100 μg/mL (below the toxic threshold of 5000 μL/mg), and none of the patients had toxic side effects.[24]

SUMMARY

Although many patients are not candidates for regional anesthesia, the opportunity to perform these techniques does occur based upon the location of the injury, associated injuries, and the patient's medical condition. Carefully performed regional anesthesia can be beneficial to the trauma patient by providing intraoperative anesthesia and perioperative analgesia.

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