1 infusion pump

1.1 Introduction

An infusion pump infuses fluids, medication or nutrients into a patient's circulatory system. It is generally used intravenously, although subcutaneous arterial and epidural infusions are occasionally used. infusion pump can administer fluids in ways that would be impractically expensive or unreliable if performed manually by nursing staff. For example, they can administer as little as 0.1 mL per hour injection (too small for a drip), injection every minute, injection with repeated boluses requested by the patient, up to maximum number per hour (e.g. in patient-controlled analgesia), or fluids whose volumes vary by the time of day.

because they can also produce quite high but controlled pressure, they can inject controlled amounts of fluids subcutaneously (beneath the skin), or epidurally (just within the surface of the central nervous system-a very popular local spinal anesthesia for childbirth).

1.2 types of infusion

The user interface of pumps usually requests details on the type of infusion from the technician or nurse that sets them up:

1. continuous infusion usually consists of small pulses of infusion, usually between 500 nanoliters and 10 milliliters, depending on the pump's design, with the rate of these pulses depending on the programmed infusion speed.

2. Intermittent infusion has a "high" infusion rate to keep the cannula open. The timings are programmable. This mode is often used to administer antibiotics, or other drugs that can irritate a blood vessel.

To get the entire dose of antibiotics into the patient, the"volume to be infused" or VTBI must be programmed for at least 30 CCs more than is in the medication bag; failure to do so can potentially result in up to half of the antibiotic being left in the IV tubing.

3. patient-controlled is infusion on-demand, usually with a preprogrammed ceiling to avoid intoxication. The rate is controlled by a pressure pad or button that can be activated by the patient. It is the method of choice for patient-controlled analgesia (PCA), in which repeated small doses of opioid analgesics are delivered, with the device coded to stop administration before a dose that may cause hazardous respiratory depression is reached.

4. Total parenteral nutrition usually requires an infusion curve similar to normal mealtimes.

some pumps offer modes in which the amounts can be scaled or controlled based on the time of day. This allows for circadian cycles which may be required for certain types of medication.

1.3 types of pump

There are two basic classes of pumps. Large volume pumps can pump fluid replacement such as saline solution, medications such as antibiotics or nutrient solutions large enough to feed a patient. Small-volume pumps infuse hormones, such as insulin, or other medicines, such as opiates.

Within these classes, some pumps are designed to be portable, others are designed to be used in a hospital, and there are special systems for charity and battlefield use.

Large-volume pumps usually use some form of peristaltic pump. Classically, they use computer-controlled rollers compressing a silicone-rubber tube through which the medicine flows. Another common form is a set of fingers that press on the tube in sequence.

Small-volume pumps usually use a computer-controlled motor turning a screw that pushes the plunger on a syringe.

The classic medical improvisation for an infusion pump is to place a blood pressure cuff around a bag of fluid. The battlefield equivalent is to place the bag under the patient. The pressure on the bag sets the infusion pressure. The pressure can actually be read-out at the cuff's indicator. The problem is that the flow varies dramatically with the cuff's pressure (or patient's weight), and the needed pressure varies with the administration route, potentially causing risk when attempted by an individual not trained in this method.

Places that must provide the least-expensive care often use pressurized infusion systems. One common system has a purpose-designed plastic "pressure bottle" pressurized with a large disposable plastic syringe. A combined flow restrictor, air filter and drip chamber helps a nurse set the flow. The parts are reusable, mass-produced sterile plastic, and can be produced by the same machines that make plastic soft-drink bottles and caps. A pressure bottle, restrictor and chamber requires more nursing attention than electronically controlled pumps. In the areas where these are used, nurses are often volunteers, or very inexpensive.

The restrictor and high pressure helps control the flow better than the improvised schemes because the high pressure through the small restrictor orifice reduces the variation of flow caused by patients' blood pressures.

An air filter is an essential safety device in a pressure infusor, to keep air out of the patients' veins. Small bubbles could cause harm in arteries, but in the veins they pass through the heart and leave in the patients' lungs. The air filter is just a membrane that passes gas but not fluid or pathogens. When a large air bubble reaches it, it bleeds off.

Some of the smallest infusion pumps use osmotic power. Basically, a bag of salt solution absorbs water through a membrane, swelling its volume. The bag presses medicine out. The rate is precisely controlled by the salt concentrations and pump volume. Osmotic pumps are usually recharged with a syringe.

2 CT scanner

2.1 Introduction

A CT scan or computed tomography scan (formerly known as computed axial tomography or CAT scan) is a medical imaging technique used in radiology to obtain detailed internal images of the body noninvasively for diagnostic purposes. The personnel that perform CT scans are called radiographers or radiology technologists. CT scanners use a rotating X-ray tube and a row of detectors placed in the gantry to measure X-ray attenuations by different tissues inside the body. The multiple X-ray measurements taken from different angles are then processed on a computer using reconstruction algorithms to produce tomographic (cross-sectional) images (virtual "slices") of a body. The use of ionizing radiation sometimes restricts its use owing to its adverse effects. However, CT can be used in patients with metallic implants or pacemakers where MRI is contraindicated.

2.2 types

1. Spiral CT :- Spinning tube, commonly called spiral CT, or helical CT, is an imaging technique in which an entire X-ray tube is spun around the central axis of the area being scanned. These are the dominant type of scanners on the market because they have been manufactured longer and offer a lower cost of production and purchase. The main limitation of this type of CT is the bulk and inertia of the equipment (X-ray tube assembly and detector array on the opposite side of the circle) which limits the speed at which the equipment can spin. Some designs use two X-ray sources and detector arrays offset by an angle, as a technique to improve temporal resolution.

2. Electron beam tomography :- Electron beam tomography (EBT) is a specific form of CT in which a large enough X-ray tube is constructed so that only the path of the electrons, travelling between the cathode and anode of the X-ray tube, are spun using deflection coils.This type had a major advantage since sweep speeds can be much faster, allowing for less blurry imaging of moving structures, such as the heart and arteries. Fewer scanners of this design have been produced when compared with spinning tube types, mainly due to the higher cost associated with building a much larger X-ray tube and detector array and limited anatomical coverage.

3. CT perfusion imaging :- CT perfusion imaging is a specific form of CT to assess flow through blood vessels whilst injecting a contrast agent. Blood flow, blood transit time, and organ blood volume, can all be calculated with reasonable sensitivity and specificity. This type of CT may be used on the heart, although sensitivity and specificity for detecting abnormalities are still lower than for other forms of CT. This may also be used on the brain, where CT perfusion imaging can often detect poor brain perfusion well before it is detected using a conventional spiral CT scan. This is better for stroke diagnosis than other CT types.

2.3 Medical use

1. Head :- CT scanning of the head is typically used to detect infarction (stroke), tumors, calcifications, haemorrhage, and bone trauma. Of the above, hypodense (dark) structures can indicate edema and infarction, hyperdense (bright) structures indicate calcifications and haemorrhage and bone trauma can be seen as disjunction in bone windows. Tumors can be detected by the swelling and anatomical distortion they cause, or by surrounding edema. CT scanning of the head is also used in CT-guided stereotactic surgery and radiosurgery for treatment of intracranial tumors, arteriovenous malformations, and other surgically treatable conditions using a device known as the N-localizer.

2. Neck :- Contrast CT is generally the initial study of choice for neck masses in adults. CT of the thyroid plays an important role in the evaluation of thyroid cancer. CT scan often incidentally finds thyroid abnormalities, and so is often the preferred investigation modality for thyroid abnormalities.

3. Lungs :- A CT scan can be used for detecting both acute and chronic changes in the lung parenchyma, the tissue of the lungs.It is particularly relevant here because normal two-dimensional X-rays do not show such defects. A variety of techniques are used, depending on the suspected abnormality. For evaluation of chronic interstitial processes such as emphysema, and fibrosis, thin sections with high spatial frequency reconstructions are used; often scans are performed both on inspiration and expiration. This special technique is called high resolution CT that produces a sampling of the lung, and not continuous images.

4. Angiography :- Computed tomography angiography (CTA) is a type of contrast CT to visualize the arteries and veins throughout the body. This ranges from arteries serving the brain to those bringing blood to the lungs, kidneys, arms and legs. An example of this type of exam is CT pulmonary angiogram (CTPA) used to diagnose pulmonary embolism (PE). It employs computed tomography and an iodine-based contrast agent to obtain an image of the pulmonary arteries.

5. Cardiac :- A CT scan of the heart is performed to gain knowledge about cardiac or coronary anatomy. Traditionally, cardiac CT scans are used to detect, diagnose, or follow up coronary artery disease. More recently CT has played a key role in the fast-evolving field of transcatheter structural heart interventions, more specifically in the transcatheter repair and replacement of heart valves.

6. Biomechanical use :- CT is used in biomechanics to quickly reveal the geometry, anatomy, density and elastic moduli of biological tissues.

3 MRI-Magnetic resonance imaging

3.1 Introduction

Magnetic resonance imaging (MRI) is a medical imaging technique used in radiology to form pictures of the anatomy andthe physiological processes of the body. MRI scanners use strong magnetic fields, magnetic field gradients, and radio waves to generate images of the organs in the body. MRI does not involve X-rays or the use of ionizing radiation,which distinguishes it from CT and PET scans. MRI is a medical application of nuclear magnetic resonance (NMR) which can also be used for imaging in other NMR applications, such as NMR spectroscopy.

3.2 mechanism

1. construction and physics :- in most medical application, hydrogen nuclei, which consists solely of a proton, that are in tissues creat a signal that is processed to form an image of the body in terms of the density of those nuclei in a specific region. Given that the protons are affected by fields from other atoms to which they are bonded, it is possible to separate responses from hydrogen in specific compounds. To perform a study, the person is positioned within an MRI scanner that forms a strong magnetic field around the area to be imaged. First, energy from an oscillating magnetic field is temporarily applied to the patient at the appropriate resonance frequency. Scanning with X and Y gradient coils causes a selected region of the patient to experience the exact magnetic field required for the energy to be absorbed. The atoms are excited by a radio frequency (RF) pulse and the resultant signal is measured by a receiving coil. The RF signal may be processed to deduce position information by looking at the changes in RF level and phase caused by varying the local magnetic field using gradient coils. As these coils are rapidly switched during the excitation and response to perform a moving line scan, they create the characteristic repetitive noise of an MRI scan as the windings move slightly due to magnetostriction. The contrast between different tissues is determined by the rate at which excited atoms return to the equilibrium state. Exogenous contrast agents may be given to the person to make the image clearer.

2. T1 and T2 :- Each tissue returns to its equilibrium state after excitation by the independent relaxation processes of T1 (spin-lattice; that is, magnetization in the same direction as the static magnetic field) and T2 (spin-spin; transverse to the static magnetic field). To create a T1-weighted image, magnetization is allowed to recover before measuring the MR signal by changing the repetition time (TR). This image weighting is useful for assessing the cerebral cortex, identifying fatty tissue, characterizing focal liver lesions, and in general, obtaining morphological information, as well as for post-contrast imaging. To create a T2-weighted image, magnetization is allowed to decay before measuring the MR signal by changing the echo time (TE). This image weighting is useful for detecting edema and inflammation, revealing white matter lesions,

and assessing zonal anatomy in the prostate and uterus.

3.3 Diagnostics

1. Usage by organ or system :- MRI has a wide range of applications in medical diagnosis and more than 25,000 scanners are estimated to be in use worldwide. MRI affects diagnosis and treatment in many specialties although the effect on improved health outcomes is disputed in certain cases.

MRI is the investigation of choice in the preoperative staging of rectal and prostate cancer and has a role in the diagnosis, staging, and follow-up of other tumors, as well as for determining areas of tissue for sampling in biobanking.

2. Neuroimaging :- MRI is the investigative tool of choice for neurological cancers over CT, as it offers better visualization of the posterior cranial fossa, containing the brainstem and the cerebellum. The contrast provided between grey and white matter makes MRI the best choice for many conditions of the central nervous system, including demyelinating diseases, dementia, cerebrovascular disease, infectious diseases, Alzheimer's disease and epilepsy. Since many images are taken milliseconds apart, it shows how the brain responds to different stimuli, enabling researchers to study both the functional and structural brain abnormalities in psychological disorders. MRI also is used in guided stereotactic surgery and radiosurgery for treatment of intracranial tumors, arteriovenous malformations, and other surgically treatable conditions using a device known as the N-localizer.New Artificial intelligence in healthcare tools have demonstrated higher image quality and morphometric analysis in neuroimaging with the application of a denoising system.

3. Cardiovascular :- Cardiac MRI is complementary to other imaging techniques, such as echocardiography, cardiac CT, and nuclear medicine. It can be used to assess the structure and the function of the heart. Its applications include assessment of myocardial ischemia and viability, cardiomyopathies, myocarditis, iron overload, vascular diseases, and congenital heart disease.

4. Musculoskeletal :- Applications in the musculoskeletal system include spinal imaging, assessment of joint disease, and soft tissue tumors. Also, MRI techniques can be used for diagnostic imaging of systemic muscle diseases including genetic muscle diseases.

5. Liver and gastrointestinal :- Hepatobiliary MR is used to detect and characterize lesions of the liver, pancreas, and bile ducts. Focal or diffuse disorders of the liver may be evaluated using diffusion-weighted, opposed-phase imaging and dynamic contrast enhancement sequences. Extracellular contrast agents are used widely in liver MRI, and newer hepatobiliary contrast agents also provide the opportunity to perform functional biliary imaging. Anatomical imaging of the bile ducts is achieved by using a heavily T2-weighted sequence in magnetic resonance cholangiopancreatography (MRCP). Functional imaging of the pancreas is performed following administration of secretin. MR enterography provides non-invasive assessment of inflammatory bowel disease and small bowel tumors. MR-colonography may play a role in the detection of large polyps in patients at increased risk of colorectal cancer.

4 Cardiac stress test

4.1 Introduction

A cardiac stress test (also referred to as a cardiac diagnostic test, cardiopulmonary exercise test, or abbreviated CPX test) is a cardiological test that measures the heart's ability to respond to external stress in a controlled clinical environment. The stress response is induced by exercise or by intravenous pharmacological stimulation.

4.2 Stress echocardiography

A stress test may be accompanied by echocardiography. The echocardiography is performed both before and after the exercise so that structural differences can be compared.

A resting echocardiogram is obtained prior to stress. The images obtained are similar to the ones obtained during a full surface echocardiogram, commonly referred to as transthoracic echocardiogram. The patient is subjected to stress in the form of exercise or chemically (usually dobutamine). After the target heart rate is achieved, 'stress' echocardiogram images are obtained. The two echocardiogram images are then compared to assess for any abnormalities in wall motion of the heart. This is used to detect obstructive coronary artery disease.

4.3 Cardiopulmonary exercise test

While also measuring breathing gases (e.g. O2, VO2), the test is often referred to as a cardiopulmonary exercise test (CPET). Common indications for a cardiopulmonary exercise test is: Evaluation of dyspnea. Work up before heart transplantion. Prognosis and risk assessment of heart failure patients. The test is also common in sport science for measuring athlete's VO2max.

4.4 Nuclear stress test

The best known example of a nuclear stress test is myocardial perfusion imaging. Typically, a radiotracer (Tc-99 sestamibi, Myoview or thallous chloride 201) may be injected during the test. After a suitable waiting period to ensure proper distribution of the radiotracer, scans are acquired with a gamma camera to capture images of the blood flow. Scans acquired before and after exercise are examined to assess the state of the coronary arteries of the patient.

4.5 Function

The American Heart Association recommends ECG treadmill testing as the first choice for patients with medium risk of coronary heart disease according to risk factors of smoking, family history of coronary artery stenosis, hypertension, diabetes and high cholesterol. In 2013, in its "Exercise Standards for Testing and Training", the AHA indicated that high frequency QRS analysis during ECG treadmill test have useful test performance for detection of coronary heart diseases.

4.6 Diagnostic value

The common approach for stress testing by American College of Cardiology and American Heart Association indicates the following.

1. Treadmill test: sensitivity 73-90 percent, specificity 50-74 percent (modified Bruce protocol)

2. Nuclear test: sensitivity 81percent, specificity 85-95 percent

(Sensitivity is the percentage of people with the condition who are correctly identified by the test as having the condition; specificity is the percentage of people without the condition are correctly identified by the test as not having the condition).

4.7 contraindications and termination conditionsa

Stress cardiac imaging is not recommended for asymptomatic, low-risk patients as part of their routine care. Some estimates show that such screening accounts for 45 percent of cardiac stress imaging, and evidence does not show that this results in better outcomes for patients. Unless high-risk markers are present, such as diabetes in patients aged over 40, peripheral arterial disease; or a risk of coronary heart diseases greater than 2 percent yearly, most health societies do not recommend the test as a routine procedure.

4.8 Adverse effects

Side effects from cardiac stress testing may include

1. Palpitations, chest pain, myocardial infarction, shortness of breath, headache nausea or fatigue.

2. Adenosine and dipyridamole can cause mild hypotension.

3. As the tracers used for this test are carcinogenic, frequent use of these tests carries a small risk of cancer.

4.9 pharmacological agents

Pharmacologic stress testing relies on coronary steal. Vasodilators are used to dilate coronary vessels, which causes increased blood velocity and flow rate in normal vessels and less of a response in stenotic vessels. This difference in response leads to a steal of flow and perfusion defects appear in cardiac nuclear scans or as ST-segment changes.

5 ECG(electrocardiogram)

5.1 Introduction

An electrocardiogram (ECG or EKG) is a record of the electrical activity of the heart over a period of time. The instrument that makes the record is the ECG machine or Electrocardiograph. Willem Einthoven invented it. It works by attaching electrodes to the outer surface of the skin.

An electrocardiogram monitors the heart. Each beat of the heart is triggered by an electrical impulse, normally generated from special cells in the upper right chamber of the heart. An electrocardiogram records these electrical signals as they travel through the heart. Doctors can use an electrocardiogram to look for patterns among these heartbeats and rhythms to diagnose various heart conditions.

5.2 Medical uses

Some indications for performing an ECG include the following:

1. Chest pain or suspected myocardial infarction (heart attack), such as ST elevated myocardial infarction (STEMI) or non-ST elevated myocardial infarction (NSTEMI)

2. Symptoms such as shortness of breath, murmurs, fainting, seizures, funny turns, or arrhythmias including new onset palpitations or monitoring of known cardiac arrhythmias

3. Medication monitoring (e.g., drug-induced QT prolongation, Digoxin toxicity) and management of overdose (e.g., tricyclic overdose)

4. Electrolyte abnormalities, such as hyperkalemia

5. Perioperative monitoring in which any form of anesthesia is involved (e.g., monitored anesthesia care, general anesthesia). This includes preoperative assessment and intraoperative and postoperative monitoring.

6. Cardiac stress testing

5.3 Electrocardiograph machines

Electrocardiograms are recorded by machines that consist of a set of electrodes connected to a central unit. Early ECG machines were constructed with analog electronics, where the signal drove a motor to print out the signal onto paper.

Most modern ECG machines include automated interpretation algorithms. This analysis calculates features such as the PR interval, QT interval, corrected QT (QTc) interval, PR axis, QRS axis, rhythm and more.

5.4 Electrodes and leads

Electrodes are the actual conductive pads attached to the body surface. Any pair of electrodes can measure the electrical potential difference between the two corresponding locations of attachment. Such a pair forms a lead. However, "leads" can also be formed between a physical electrode and a virtual electrode, known as Wilson's central terminal (WCT), whose potential is defined as the average potential measured by three limb electrodes that are attached to the right arm, the left arm, and the left foot, respectively.

5.5 Electrophysiology

The study of the conduction system of the heart is called cardiac electrophysiology (EP).

An EP study is performed via a right-sided cardiac catheterization: a wire with an electrode at its tip is inserted into the right heart chambers from a peripheral vein, and placed in various positions in close proximity to the conduction system so that the electrical activity of that system can be recorded.

Standard catheter positions for an EP study include "high right atrium" or hRA near the sinus node, a "His" across the septal wall of the tricuspid valve to measure bundle of His, a "coronary sinus" into the coronary sinus, and a "right ventricle" in the apex of the right ventricle.

5.6 Interpretation

Interpretation of the ECG is fundamentally about understanding the electrical conduction system of the heart. Normal conduction starts and propagates in a predictable pattern, and deviation from this pattern can be a normal variation or be pathological.

An ECG does not equate with mechanical pumping activity of the heart, for example, pulseless electrical activity produces an ECG that should pump blood but no pulses are felt (and constitutes a medical emergency and CPR should be performed). Ventricular fibrillation produces an ECG but is too dysfunctional to produce a life-sustaining cardiac output.

Ultimately, an echocardiogram or other anatomical imaging modality is useful in assessing the mechanical function of the heart.