

Volume 6 - Issue 4, 2006 - Features

Power Injectors in Computed Tomography

Increasing Medical Safety

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Many Computed Tomography (CT) exams necessitate the use of intravenous injection of contrast media, to make specific organs, blood vessels or other tissue types stand out from surrounding structures. Until the early 1990's, CT scanners employed long scan times using 'step and shoot' technology.

To scan an average patient for the chest, abdomen and pelvis with 10mm sections at 15mm centres would require some 50 sections at 10 seconds each- about 5 minutes of scan time for a very breathless patient who has been asked to breath hold for 50 separate scans. Initial use of contrast involved the radiologist in the scan room performing a hand injection of contrast media, typically 100 mls. It was only possible to acquire a relatively short number of scans with the contrast in the optimum circulatory phase and there were concerns about the consistency of timing and flow rates, which were very operator dependant.

New Technology Saves Time

The advent of slip ring technology allowed a scan to be acquired as a single volume of information, (spiral or helical scanners), reducing scan times to approximately 20 seconds per body area. Multi-detector row scanners now allow scan times of only a few seconds per body region. Many CT protocols now require multiphase scans, where one body region is imaged with the contrast at different circulatory phases, using a single contrast bolus. New power injectors need to allow tight control of flow rate, volume and timing of the injection. Recent developments in cardiac and angiographic CT have shown advantages in using a saline bolus following the contrast, reducing the volume of contrast required. Several manufacturers are currently offering double headed injectors in the UK market, including Medrad's Stellant CT Injector, Medtron's Injexon CT 2 Injector, the E-Z-EM Empower CT Injector and Tyco Healthcare's Optivision DH CT Injector

Safety Considerations for Power Injectors

As injections are often remotely triggered by the operator in the CT control room, there are two main safety issues. The first involves the injection of air into the vein, potentially causing an air embolus in the pulmonary arteries or cerebral circulation, causing a stroke (in the presence of an intracardiac right to left shunt). The volume of air may be a few mls. caused by not purging the connecting line or may be as much as 100 mls., if an empty syringe is inadvertently used. The second, extravasation of the contrast into the surrounding tissues, can cause damage due to toxicity. This is usually very painful, and may lead to breakdown of the tissues. CT injectors currently on the market address these problems in different ways but share many common characteristics.

Characteristics of Power Injectors

Flow Rate

- this is adjusted in steps of 0.1 ml. from 0.1 - 9.9/10 mls. If the flow rate is too high for the vein being used it can cause an increase in pressure leading to venous rupture and resultant extravasation into the subcutaneous tissues.

Delivery Pressure

- to reduce the risk of extravasation it is essential to be able to programme a maximum pressure limit which may vary depending on size of the vein and flow rate of the injection. Once this pressure limit is reached, flow rate is reduced and a warning flashes on the screen. The operator then has the option to pause the injection to check that extravasation has not occurred.

Volume Ranges

- different volumes of contrast and saline will be required dependant on the area being scanned, scan protocol and patient considerations such as weight of the patient and kidney function. All the above injectors have a maximum syringe size of 200 mls. for both the contrast and saline sides.

Syringe Warmer

- To reduce viscosity, the contrast is pre-warmed to near body temperature which reduces adverse effects. Once the syringe is positioned on the injector it is kept at this temperature until required.

Configuration

- injectors are available as either ceiling- or pedestal-mounted.

Specific Features

- The E-Z-EM Empower injector has a patented patch, placed over the injection site that detects change of electrical impedance in the skin caused by extravasation and pauses the procedure before harm is done. The device registers extravasation volumes of less than 20mls. This injector also has a tilt sensor/lockout which prevents an injection unless the injector is tilted vertically downwards beyond 270 degrees to help minimise the risk of air bubbles reaching the syringe tip. System arming and flow rate manipulation can all be performed at the injector head.
- Medrad's Stellant injector has an automated system for filling syringes with contrast and saline and for advancing/ retracting the syringe plungers which reduces loading/ unloading time and increases efficiency. There is a patented system to prime the extension tube which controls waste and spillage of contrast and a 'keep vein open' feature which pulses a small amount of saline to maintain vein patency. For cardiac scanning this system can inject saline and contrast concurrently in order to provide images of the right side of the heart with dilute contrast. The syringes used have moulded fluid dots allowing easier detection of air in the syringe.
- The Medtron Injectron CT2 has overcome the problem of trip hazards from electric cables by using a wireless touch screen remote control. It has the ability to inject saline and contrast concurrently and also has a 'keep vein open' feature.
- Tyco Healthcare's OptiVantage DH has the ability to use prefilled syringes. According to a study by the American Society of Radiologic Technologists, the use of prefilled syringes was based upon four factors; saving time, improving cost effectiveness, enhancing healthcare quality and improving patient safety. This injector is programmable at the injector head and also features a tilt sensor/lockout to reduce the risk of air embolus. This injector also has a patency check feature similar to the Medtron 'keep vein open' feature.

Advantages of Intravenous Administration

In current practice, intravenous contrast is used almost universally for body scanning unless there are specific clinical reasons or where contrast is clearly unnecessary. If contrast is not used then the soft tissues of the body cannot be distinguished from one another. Contrast may be taken up by normal structures differently, depending upon the nature of their blood supply, enabling us to appreciate differences. Diseased organs may exhibit abnormal uptake or enhancement of contrast. Upon injection of contrast through a peripheral arm vein, contrast flows first through the right side of the heart, through the lungs, onto the left side of the heart and then out of the heart into the arterial system and perfuses through organs of the body. So it follows, that scan timing related to contrast injection rate and circulation time of the patient may allow imaging of the organs in the circulatory phase of choice (Figure 1 a-c).

Also, evaluation of blood vessels can be made very rapidly, with many invasive procedures now replaced by a CT scan. For example, the whole heart may be scanned in less than 10 seconds and we are able to evaluate not only the coronary arteries but also gross morphological cardiac structure and function.

Conclusion

CT is being increasingly used as a rapid, easily accessible 'one stop shop' for the diagnosis of acute chest pain, which is a very common clinical presentation for a wide variety of potentially lifethreatening pathologies. The prescriptive and careful approach to the use of intravenous contrast use has become vitally important, as CT technology continues to advance at a rapid rate.

Published on : Sun, 1 Oct 2006