Contrast Media

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Although, contrast media is known to cause adverse reactions, the actual reasons for adverse reactions remains unknown. There are two common theories that are used to describe adverse reactions to intravenous iodinated contrast media. Adverse reactions are classified as physiochemotoxic or idiosyncratic in nature. The first category relates adverse reactions to the chemotoxicity of the contrast media. Physiochemotoxic reactions are believed to result from contrast media's ability to upset the homeostasis of the body especially the blood and blood circulation. The term hemodynamics is used to describe blood and the factors that effect blood circulation within the body. Injected contrast media always has the potential to alter blood cells and the circulation of blood as well as other organ systems in the body. The body systems most commonly effected by physiological changes that can be produced by contrast media are the cardiovascular, respiratory, urinary, gastrointestinal, neurologic, and the integumentary systems. The integumentary system includes the skin and its attachments including the hair and nails which are dermal derivatives. The integumentary system is sometimes referred to as the cutaneous system. Under certain circumstances the systems of the body may not be able to compensate for the physiological changes brought on by the introduction of contrast media. Physiochemotoxic reactions are commonly related to the following:

1. Physical properties of the contrast media.
2. Iodine concentration of the contrast media.
3. Total dose or volume of the contrast media injected.
4. Rate or speed of the injection.

1. The **physical properties** of the contrast media include the ions or particles associated with the chemical breakdown of the contrast media when it enters a solution, the number and size of the iodine molecules, and the number and size of the molecules of any chemical additive. The chemical composition of ionic and non-ionic contrast media contains iodine. One of the primary differences between ionic and non-ionic contrast media is that an ionic compound dissociates or dissolves into charged particles when it enters a solution such as blood. Ionic media breakdown into cations, positively charged particles and anions, negatively charged particles. For every three iodine molecules present in an ionic media, one cation and one anion are produced when it enters a solution. Ionic contrast media are generally referred to as 3:2 compounds. The cations and anions are the direct result of the disassociation of compounds that are attached as "side chains" to the contrast media molecule. Sodium and/or meglumine are cations and diatrizoate and iothalamate are the common anions. Non-ionic contrast media do not dissolve into charged particles when it enters a solution. For every three iodine molecules in a non-ionic solution, one neutral molecule is produced. Non-ionic contrast media are referred to as 3:1 compounds. The resultant ion charges from an ionic compound have the potential to disrupt the electrical charges associated with the brain as well as the heart. Neurotoxicity is the term that describes the potential that the ionic charges have for disrupting the electrical charges of the brain.

The **osmolality** of a solution is the measurement of the number of molecules and particles in a solution per kilogram of water. Osmolality can be described as a measurement of the number of molecules that can crowd out or displace water molecules in a kilogram of water. The radiographic significance of the osmolality value of contrast media is that it is higher than the osmolality value of blood plasma. Any solution that has an osmolality value greater than blood plasma is said to be a hyperosmolar solution. Therefore, ionic and non-ionic contrast media are hyperosmolar solutions when compared to blood plasma. The following are examples of approximate average osmolality values of blood plasma, cerebrospinal fluid, non-ionic contrast media, and ionic contrast media.

Blood Plasma and Cerebrospinal Fluid	300
Non-Ionic CM	400-750
Ionic CM	1400-1800

Contrast media is primarily divided into two categories, **high osmolar contrast media (HOCM)** and **low osmolar contrast media (LOCM)**. Most non-ionic agents are placed into the LOCM category while all ionic agents are in the HOCM category. An injection of contrast media, especially ionic HOCM, results in a big increase in the number of particles contained in the vascular system. The introduction of contrast media into the vascular system causes water from body tissue (cells) to move into the vascular system in an attempt to equalize concentrations. The contrast media particles draw plasma water towards them therefore, water from body tissue (cells) rapidly moves into the vascular system via the capillary membranes to balance or equalize the situation. This process is known as osmosis. The blood vessels dilate in an attempt to compensate from the increased fluid volume. Sometimes the fluid shift may be too dramatic for the vessels to handle therefore, fluid actually extravasates into the surrounding tissues. Extravasation is the leaking of a fluid from the vessel into surrounding tissue. Hypervolemia is the term that is used to describe an abnormal increase in the volume of circulating fluids or blood. The rapid fluid movement, especially water, throughout the vascular system is believed to contribute to pain associated with vessel dilation, flushing, damage to the vascular endothelium, red cell changes, nausea, vomiting, and dehydration. The osmotic effect can cause the arteries of the kidneys to expand. When the arteries expand vasoconstrictors are released to compensate for the artery expansion. The vasoconstrictors constrict the arteries resulting in a rapid opening and closing action of the arteries. The result of this action is a diminished blood supply to kidneys which can lead to total shut down of the kidneys. There is also a chance that the arteries may be constricted enough and totally close. The body must attempt to regulate the fluid overload in the vascular system. If the kidneys are non-functional, the fluid is forced to seek other avenues of escape causing fluid overload to occur in other body systems. One of the major results of this event is pulmonary edema.

2. The **iodine concentration** is determined by the number of iodine molecules in milligrams present in a milliliter of a solution (mg/ml). The iodine concentration of an individual contrast agent determines how radiopaque the agent will be. The higher the iodine concentration, the better the chance that more x-ray photons will be absorbed therefore, that particular contrast agent maybe more radiopaque than a comparative low iodine concentrated agent. The iodine concentration has an effect on the severity of an adverse reaction. **The higher the iodine concentration, the greater the risk of an adverse reaction**.

3. The **total volume** or dose is dependent upon several factors. Iodine concentration of the contrast media, type of contrast media being injected (ionic or non-ionic), body weight, anatomical structures or regions, speed of the injection and age or disease process that could increase the risk of an adverse reaction. " The acute lethal dose (LD50) is the dose of a contrast medium required to cause a mortality rate of 50% following an intravenous injection of 1 minute duration" (Katzberg, 1992). Increasing the injected volume increases the possibility of an adverse reaction occurring. An injection of a large amount of contrast media usually is accompanied by the use of a lower iodine concentrated agent.

4. The rate or **speed of contrast media injections** is an important factor associated with physiochemotoxic reactions. Increasing the speed or rate of injection may increase the risk of an adverse reaction occurring. The term that is associated with the thickness of a contrast agent is viscosity. **Viscosity** describes the thickness or **resistance to flow** of a contrast agent. The thickness of the contrast agent is related to the concentration , the size of the molecules in a specific contrast agent, and the temperature of the contrast agent. The thickness or viscosity effects the rate that the contrast media can be injected. Contrast medias with a higher viscosity values will have to be injected at a slower rate. Heating the contrast media , usually to body temperature, reduces viscosity. All power injection devices are equipped with a "warming pad" covering a portion of the syringe. The warming device heats the filled syringe to a temperature that is approximate to human body temperature. The **warming** of the contrast media **reduces the viscosity** which decreases the risk of impeding the flow. Iodine concentration, viscosity, temperature of the contrast media, catheter inner diameter, catheter length, and the number of catheter holes are all factors that influence contrast media flow.

The second theory classifies adverse reactions to contrast media as **idiosynchratic** reactions. Idiosynchratic reactions may not be influenced by the iodine concentration, chemical properties, and rate or volume of the injected contrast media. Idosynchratic reactions resemble **allergic reactions** or a hypersensitivity to a particular substance, in this case the substance is iodinated contrast media. The reason for this type of reaction remains unknown. A comparison, however, has been made to allergic reactions that occur in hypersensitivity to grains and pollen. The most common term for the "allergy type" reaction is **anaphylactoid reaction**. Antibodies are formed in response to antigens which produces the symptoms of an allergy. The antibody-antigen response stimulates the release of **histamine**.

Histamine is a naturally occurring chemical in the body and its release in the body is the most important mediator in allergic reactions. Histamine is found in most tissues and in specific cells of the lungs, gastrointestinal mucosa, gastrointestinal tract, lining of blood vessels, and parts of the central nervous systems. Histamine primarily effects the cardiovascular, gastrointestinal, respiratory, and central nervous systems. Histamine constricts smooth muscle, dilates arterioles, constricts venules, produces localized edema, accelerates heart rate, lowers blood pressure, increases gastric secretions, and increases mucous secretions. When an excessive amount of histamine is released in the body and the vascular system becomes over loaded, histamine extravasates outside the vessels into the surrounding tissues. The extravasation of histamine can cause inflammation, swelling and reddening of the surrounding tissue which is urticaria or hives. "Watery eyes", "runny nose", migraine headaches, nausea, vomiting, laryngospasm, and bronchospasm are all effects related to an excessive amount of histamine release in the body.

Idiosyncratic or anaphylactoid reactions to contrast media are catagorized as either mild, moderate, or severe. Contrast media reactions are classified in proportion to the type of treatment that is utilized to treat the reaction. Anytime contrast media is introduced into the body there exists a possibility that an adverse reaction may occur. The radiologic technologist's immediate recognition and response to an adverse reaction is very important because it can save a patient's life. Technologists must become familiar with radiology department protocols regarding adverse reactions to contrast media as well as all emergency situations that may arise. The next module in this series will cover indications, contraindications including disease processes , treatment of adverse reactions, and drug pharmacology.

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