MR Contrast Agents Overview

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Target audience: Radiologists, MRI physicists and students using gadolinium contrast agents

Objectives

1. To review the physicochemical properties of gadolinium based contrast agents (GBCAs). Non gadolinium based contrast agents will not be discussed.
2. To review clinical use of GBCAs using case examples.
3. To review contra-indications and adverse events of GBCAs.
4. To review current data on NSF.

In this presentation, we will review the following:

1. Rationale for the use of gadolinium based contrast agents (GBCAs): these agents are necessary in most clinical scenarios for diagnosing and characterizing focal and diffuse disease by increasing contrast resolution and SNR, for MR angiography and venography, and for quantification of perfusion/flow and permeability in tissues/tumors.
2. Physicochemical properties of GBCAs, include:
    a. Relaxivity: defined by degree of T1 and T2 shortening effect of GBCAs, given by the following equation: $T1 \approx \frac{1}{R1\,[Gd]}$
    T1 shortening (signal gain) predominates at low concentrations, while T2 shortening (signal loss) predominates at high concentrations.
    a. Chemical structure: GBCAs consist of the combination of gadolinium and a chelating agent. They can be categorized into linear and macrocyclic agents and by their charge (ionic vs. non-ionic).
    b. Pharmacokinetic properties: After intravenous injection, GBCAs distribute within the extracellular interstitial space, with a distribution half-life of ≈10 min. Extracellular (EC) GBCAs are excreted by the kidneys, with an elimination half-life of approximately 90 min in patients with normal renal function. Over 90% of the injected dose is eliminated through renal excretion within the first 24 hours. Patients with reduced kidney function have a prolonged elimination half-life (up to several hours, depending on the degree of renal impairment) with >80% of the administered dose excreted over the subsequent week. However, renal impairment does not affect the extracellular distribution half-life.
    c. Thermodynamic stability: It has been suggested that thermodynamic stability relates to the risk of transmetallation (gadolinium can be exchanged between ligands or even be released as a free Gd3+ ion in the body) which has been incriminated in NSF triggering.
    d. Concentration and dose
    e. Extracellular vs. dual agents vs. blood pool agents:
        i. EC agents: include the mostly used agents, Gadoterate (Dotarem), Gadopentetate (Magnevist), Gadodiamide (Omniscan), Gadoversertamide (OptiMARK), Gadobutrol (Gadavist/Gadovist) and Gadoteridol (ProHance)
        ii. Dual agents (extracellular and liver specific): Gadobenate (MultiHance) with 3-5% hepatobiliary elimination and Gadoxetic acid (Eovist/Primovist) with 50% hepatobiliary elimination.

iii. Blood pool agent: Gadofosveset (Ablavar/Vasovist), this agent has high albumin affinity.

3. Contra-indications of GBCAs: these include
    a. Pregnancy.
    b. History of documented prior severe allergic reaction to GBCAs.
    c. Acute renal insufficiency.
    d. Severe chronic renal insufficiency (eGFR <30).
4. Adverse events of GBCAs: these include mild, moderate and severe allergic reactions, and other adverse events.
5. Updated information on NSF: since the initial description of NSF cases, and the suspected link with GBCA, there has been wide adoption of more restrictive rules on the use of GBCAs in patients with decreased renal function. This has led to a significant reduction of the number of cases.
6. Review of current ACR and ESUR policies on GBCA administration.

References

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