W H I T E P A P E R

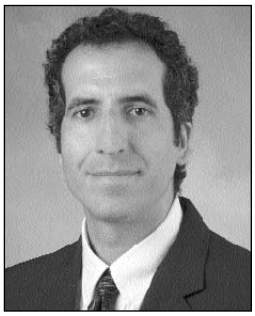
Evaluating Barium Sulfate and Iodinated Contrast Media for CT:

Perspectives on Transit Time, Density, Stability, and Convenience

Purpose: To retrospectively evaluate the transit time, density, stability, and convenience of barium sulfate and oral iodinated contrast media for CT abdomen/pelvis studies.

Materials and Methods: Dr. Peter Quagliano of McGuire Veterans Affairs Medical Center (VAMC) in Richmond, VA has performed extensive research on barium sulfate and oral iodinated contrast media in CT abdomen/pelvis studies. Dr. Quagliano participated in a telephone interview regarding his findings that were previously published in the American Journal of Roentgenology (1997, 1999).

Conclusion: In Dr. Quagliano's opinion, barium sulfate is an excellent default contrast media for CT abdomen/pelvis studies because: it contains sorbitol as a component which aids in transit; it maintains a steady Hounsfield unit (HU) attenuation; and its stabilized pre-mixed solutions are available in a variety of well accepted flavors.



Peter Vincent Quagliano, MD
Staff Radiologist, Radiology Service, McGuire Veterans Affairs Medical Center, Richmond, Virginia

Assistant Professor of Radiology at the Medical College of Virginia, Richmond, Virginia

Introduction

Within the radiology community there is a fairly even division between those who use barium sulfate and those who prefer iodinated contrasts for abdomen/pelvis CT studies. Transit time, cost, convenience, and patient acceptance have been key factors in reaching the decision to use one type of contrast agent over the other. Less common issues, but of no less importance, are those concerning the maintenance of consistent contrast density throughout the digestive tract, and the stability of prepared mixtures over time. Often, however, the understanding of these factors may be based on old information, anecdotal evidence, and even misconceptions.

Since 1994, Peter Quagliano, MD, of McGuire Veterans Affairs Medical Center (VAMC) in Richmond, VA, has been studying these factors. While he recognizes the value of both barium and iodine contrast media types for specific patient populations, he supports the use of barium sulfate as the default contrast agent for CT abdomen/pelvis studies. His reasons are based on a balanced consideration of all factors, including certain technical characteristics of iodinated contrast that are not widely understood.

Transit Time

In 1997 Dr. Quagliano conducted a comparison study of transit times using three different barium sulfate formulations and one iodinated contrast agent.[1] The study involved 220 patients divided into four groups, each group receiving one of the four agents. Dr. Quagliano found that all three barium sulfate suspensions progressed farther through the digestive tract, for a given unit of time, than did the iodinated contrast.

> Barium sulfate suspensions progressed farther through the digestive tract than the iodinated contrast.

This result may surprise some radiologists who subscribe to a long-held belief that iodinated agents provide faster transit times than barium sulfate. This misconception may be based on experience with full strength iodinated contrast agents administered for conventional GI fluoroscopic examinations, where the hypertonic iodinated contrast agent does, in fact, cause water influx into the bowel lumen and more rapid transit. For CT examinations, however, the full strength ionic iodinated contrast agent is diluted to 3-4% of its initial (60%) concentration, which produces a hypotonic solution. The dilute diatrizoate salts do appear to cause some improvement in bowel transit time, perhaps due to a direct chemical effect on the bowel. The transit time, however, is still slower than the commercial barium contrast agents because the iodinated contrast agent lacks the addition of an osmotic agent such as the poorly-absorbed sorbitol sugar. The presence of sorbitol along with other refinements in barium sulfate preparations over the years have yielded a product that is formulated to optimize the transit time while minimizing the risk of diarrhea.

Density

The maintenance of a constant Hounsfield unit (HU) attenuation throughout the bowel is a desirable characteristic of an ideal oral contrast agent for CT. Since barium sulfate and the diatrizoate salts in iodinated contrast are not absorbed by the bowel, maintenance of a constant HU requires that very little water be absorbed from, or added to, the contrast agents during their transit through the GI tract. Barium contrast manufacturers, such as E-Z-EM, attempt to achieve this effect by the addition of an appropriate amount of either sorbitol or mannitol. In the 1997 study by Quagliano, et. al., the three barium products maintained a reasonably constant HU throughout the GI tract. Absorption of water from the bowel lumen during passage of the hyposmolal iodinated contrast solution through the GI tract, however, resulted in concentration of the contrast solution with a significant increase in HU. See Figure 1.

> All three barium products maintained a reasonably constant HU throughout the GI tract.

According to Dr. Quagliano, "In our experience, when iodinated contrast is mixed with a flavored beverage at a ratio that provides our desired HU attenuation in the stomach (225-250 HU), the contrast agent becomes progressively more radio-dense as it passes through the GI tract and water is absorbed. The HU

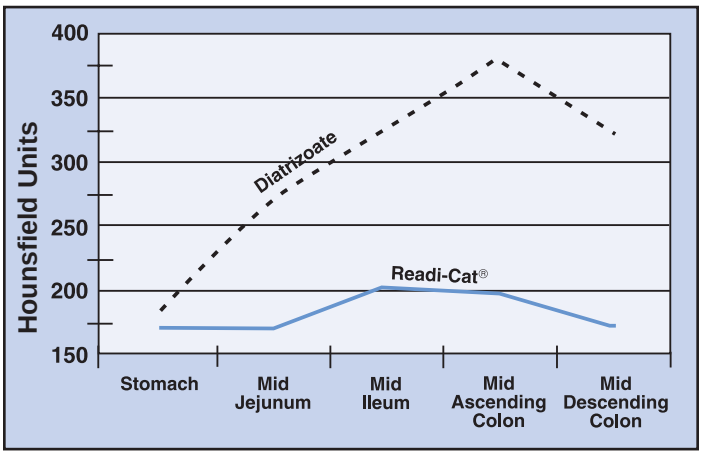


Figure 1. *Graphical representation of average HU density at various stages within the GI tract for E-Z-EM's Readi-Cat barium sulfate contrast, compared to diatrizoate (iodinated contrast) mixed with Kool-Aid®.*

of the iodinated contrast in the distal small bowel and colon can average as high as 350-450 HU. This has two drawbacks. First, the total volume remaining in the bowel lumen decreases as water is absorbed and this leads to less bowel distention and filling than we intended, based on the volume consumed. Second, as the average HU rises above 300 HU, more light is transmitted from the viewbox or viewing monitor through the contrast-filled bowel lumen to the interpreter's eye. Above 300 HU, we have found the amount of light transmitted through the oral contrast displeasing, as our eyes strain to evaluate the soft tissue structures in the body other than the bright white contrasted-filled bowel lumen."

Stability

A factor not often considered when evaluating iodinated contrast agents is the question of precipitation after mixing. According to Dr. Quagliano, "When we mix iodinated contrast agents with a flavored drink mix

> "...we have seen clumps of precipitated (iodinated) contrast in the dependent portions of the stomach and proximal small bowel."

we strive to use the solution as soon as possible, ideally within several hours of mixing. We assume the mixture to be fairly stable, but there are no formal stability studies of which I am aware, so we really don't know what constitutes an acceptable shelf life."

"What we do know is that precipitation of iodinated contrast does occur, and that it is a pH and time-related phenomenon. In fact, if you lower the pH enough, precipitate will form right before your eyes.[2] At the pH of citrus-flavored drinks such as Crystal Light® and Kool-Aid, a pH range of 2.4 to 3.5, precipitation will not occur immediately, but will occur slowly over time. The citric acid used to increase the tartness of these beverages has the effect of lowering the pH."

Precipitation is an important consideration because the precipitated iodine salts no longer contribute to the density of the ingested liquid product and the HU of the ingested contrast agent decreases in proportion to the amount of precipitation that occurs. "Even if precipitation does not occur in the mixing container," points out Dr. Quagliano, "the pH of the contrast media may be lowered even further when it mixes with acid in the stomach. In some patients we have seen clumps of precipitated (iodinated) contrast in the dependent portions of the stomach and proximal small bowel."

Convenience and Choosing a Standard

While Dr. Quagliano believes that both barium sulfate and iodinated oral contrast agents have valuable roles in CT studies of the abdomen/pelvis, he considers barium products to be currently the most convenient choice for obtaining excellent imaging characteristics. Iodine products may be more palatable, but in order to try to make them as effective as the barium agents for imaging, they must be mixed with a flavored drink mix and sorbitol, which may be inconvenient. Dr. Quagliano believes that, "When properly mixed with the right amount of sorbitol and flavored beverage, iodinated contrast can make an excellent imaging agent. Because of our concerns regarding precipitation and stability, on those occasions when we use

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iodinated contrast we mix each dose immediately before administration to the patient. The preparation of the iodinated contrast, however, is less convenient than the shake-and-serve ease of the barium sulfate formulations. We tend to reserve the use of iodinated contrast for our patients who have trouble drinking the barium contrast or where bowel perforation is a concern. This, however, involves only a small percentage of patients at our facility."

References:
1. Quagliano P, Austin, Jr R. Oral contrast agents for CT: A comparison of transit times and side effects. *American Journal of Roentgenology* (Published Abstract) 1997; 168:37.

2. Quagliano P, Vallarino L. Parameters affecting the precipitation of ionic iodinated contrast media. *American Journal of Roentgenology* (Published Abstract) 1999; 172:43.

E-Z-EM manufactures and markets a wide range of CT oral contrast products. All products in the range have essentially similar clinical properties, and the decision to choose one over another is based on non-medical criteria such as convenience or taste preference. Not all products manufactured by E-Z-EM are available in all global markets. Brand names used for E-Z-EM CT oral contrast products in various global territories include Smoothie, Readi-Cat®, E-Z-Cat®, E-Z-Cat® Dry, and BARICAT®.

E-Z-EM, INC.

Global Headquarters
1111 Marcus Avenue, Suite LL26
Lake Success, NY 11042 USA
PHONE: 516-333-8230
TOLL FREE: 1-800-544-4624 (US only)
FAX: 516-302-2919
www.ezem.com

E-Z-EM Ltd.

International Office
Avonbury Business Park
Howes Lane, Bicester
OX26 2UA, United Kingdom
Orderline: 0800 18 17 33 (UK only)
Phone: +44 (0) 1869 366900
Fax: +44 (0) 1869 366999
Email: information@ezem.co.uk

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