Research Fuels Debate over Bismuth Breast Shields

Based on mounting evidence, the American Association of Physicists in Medicine (AAPM) is recommending against using bismuth breast shields in a forthcoming position statement.

While not disputing that bismuth breast shields reduce radiation, leading medical physicists contend the shields can cause errors in CT numbers or create streak artifacts that negatively impact image quality, according to AAPM President J. Anthony Seibert, Ph.D., a professor of diagnostic imaging physics at the University of California, Davis.

"That breast dose can be reduced with shields is certainly a fact; however, because the X-ray tube goes around to the other side during 360-degree rotation during acquisition, photons that irradiate the breast are subsequently attenuated by the shield which would, in the best scenario, be unattenuated," Dr. Seibert said.

Although AAPM is not endorsing any one technique, many physicists contend that organ-based angular tube current modulation (TCM) offers similar levels of dose reduction at equivalent or improved levels of image quality as breast shields.

Since breast shields were introduced in 1997, conflicting data regarding their impact on diagnostic accuracy have emerged, creating two schools of thought. Many radiologists maintain that the shields reduce radiation without sacrificing diagnostic quality, whereas others feel that the negatives outweigh any benefits.

Research from investigators on both sides of the issue was presented at RSNA 2010.
Tube Current Method Reduces Noise

Dose reduction, image noise and CT number accuracy achieved on an adult thorax phantom using bismuth shielding, organ-based tube current modulation (TCM) and global reduction of the tube current. The reference technique used conventional TCM and a routine clinical thorax protocol. Similar dose reduction was achieved with the three techniques. Organ-based TCM provided the best image quality, showing no increase in image noise or decrease in CT number accuracy. Bismuth shielding increased the CT numbers in the lung and heart regions relative to the correct values. Globally reducing the tube current showed a similar noise increase as bismuth shielding but maintained CT number accuracy.

In a study comparing bismuth shielding with organ-based angular TCM and global reduction of tube current, lead author Cynthia H. McCollough, Ph.D., director of the CT Clinical Innovation Center at the Mayo Clinic in Rochester, Minn., and her team demonstrated that organ-based TCM and global tube current reduction offer similar levels of dose reduction to the breast at equivalent or improved levels of image quality.

"Simply reducing the tube current can provide the same dose reduction as bismuth shielding at similar image noise levels, but without causing errors in CT numbers or streak artifacts," Dr. McCollough said.

Jia Wang, Ph.D., a research fellow in Mayo's CT Clinical Innovation Center, studied thoracic phantoms representing patient sizes ranging from a typical 3-year-old to a
large adult. He measured dose to the anterior surface of the phantoms using an ionization chamber with and without bismuth shields. After calculating dose reduction achieved by applying the shields, he decreased the tube current to match the dose reduction achieved with the shield. He then repeated the scan and dose measurements at the lower tube current without shields.

"As we expected, the same dose reduction was achieved by lowering scanner output by the appropriate amount as by using bismuth shields," Dr. Wang said. "However, the dose reduction achieved using shields was limited to the anterior surface of the phantom, while lowering the tube current reduced the dose by the same amount to all phantom surfaces. As expected, total dose to the patient is lower when the tube current is globally decreased compared to when using bismuth shielding."

In comparing image noise in the heart and lung regions of the phantoms, Dr. Wang and colleagues found a similar noise increase between the use of bismuth shielding and reducing tube current throughout the entire scan. While shielding altered CT numbers and generated streak artifacts, reducing tube current did not create these problems.

All experiments were repeated using organ-based TCM, which decreased tube current to the anterior surface but increased it to the lateral and posterior surfaces. With this approach, image noise did not increase, CT numbers remained accurate and no artifacts were produced. Also, dose reduction to the breast was similar to that generated by bismuth shielding.

**Artifacts Don't Limit Diagnostic Accuracy**

In a second study, researchers at Rhode Island Hospital, affiliated with Brown University in Providence, demonstrated that the shields reduced radiation without impacting diagnostic quality. Lead author Kathryn McGillen, M.D., a second-year diagnostic radiology resident at the university, and colleagues reviewed the first 50 consecutive patients receiving a non-contrast chest CT who had also received a prior chest CT at the hospital before the routine use of breast shields. Researchers used the first 25 patients who had both exams performed on a 64-slice CT scanner followed by another 25 who had both scans performed on a 16-slice scanner.

Two radiologists evaluated the studies for diagnosis and the presence of artifact. No diagnostic errors, missed findings or non-diagnostic examinations were identified, although artifact occurred in 62 percent of shielded patients, researchers found. Streak artifact was most common in superficial soft tissues nearest the shield (62 percent), followed by artifact extending into the mediastinum (16 percent). In one patient, artifact limited visualization of a breast mass; however, the finding was not missed.
The distance of shield placement from the skin proportionately affected artifact and noise, researchers demonstrated. The further away the shield, the less artifact and noise, with no difference between scans performed on a 16- or 64-slice CT scanner.

While breast shields commonly result in beam hardening and streak artifact, researchers did not find the artifacts to limit diagnostic accuracy in any of the study participants, Dr. McGillen said.

She stressed that this retrospective study was unique in using patients rather than phantoms that use surrogate markers to evaluate noise and artifacts.

"By using patients, we are able to look at the actual diagnostic impact of artifact and found that it did not affect diagnosis," she said. "Therefore the issue of shielding, artifact and noise become less relevant. Additionally, by keeping the breast shield off of the patient by approximately 2 cm, artifact becomes inconsequential while dose savings remain unchanged."

Rhode Island Hospital has been using breast shields on all scanned patients since mid-2008, Dr. McGillen said. "There is just no good reason not to use one," she said.

**Data Remain Inconclusive**

Issuance of the AAPM position statement notwithstanding, the matter is hardly settled—primarily because data do not yet support one clear answer. In the meantime, experts continue to explore positive and negative aspects of both techniques.

"While I agree that organ-based TCM can achieve about the same dose reduction as bismuth shields, this capability is not available on the overwhelming majority of CT scanners in the U.S. and is unlikely to be in the near future," said Robert Gould, Sc.D., a professor and vice-chair, Technology and Capital Projects Department of Radiology and Biomedical Imaging, at the University of California San Francisco. "It should also be noted that the effectiveness of TCM in reducing dose depends on the patient's anatomy and its use also requires a degree of care by the technologist to maximize the benefits."

While agreeing AAPM should encourage the use of TCM, Dr. Gould feels the use of breast shields should not yet be discouraged. "While bismuth shields must be positioned appropriately so that streak artifacts through the anatomy are minimized and do not interfere with the diagnostic quality of the images, we have found that with some instruction, technologists have little difficulty in placing the shields to avoid problematic artifacts," Dr. Gould said.

"Until TCM becomes more widely available, I would still encourage breast shields as
a methodology proven to reduce breast dose that is easily implemented, inexpensive and widely available," Dr. Gould said.