Bismuth Breast and Thyroid Shield Implementation for Pediatric CT

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EXECUTIVE SUMMARY

- Studies have indicated that infants and children are as much as ten times more susceptible to carcinogenesis from radiation than adults. Because data show bismuth breast and thyroid shields decrease radiation dose to sensitive areas without changes in image quality, Children's Healthcare of Atlanta implemented the use of bismuth shields in all patients undergoing CT examinations.
- Staff education regarding the use of bismuth shielding was key to the success of this program. Their understanding of the benefits would ultimately assist in their support of shield use in the CT department.
- This program was made possible through a grant from the AHRA & Toshiba Putting Patients First Program. Otherwise, the cost of bismuth shielding would be supported by the operating budget of the organization and, with the decline in CT volume reported at many healthcare institutions, this cost may be too high for many hospitals.

Studies have indicated that infants and children are as much as ten times more susceptible to carcinogenesis from radiation than adults. Today, computed tomography (CT) scans play a critical role in the diagnosis and management of most patients with complex medical conditions. As the use of CT imaging increases in the pediatric population so does the risk for latent carcinogenic effects of radiation on radiosensitive tissues including breast and thyroid. Considering the heightened sensitivity of young patients to radiation's ill effects, radiologists and staff at Children's Healthcare of Atlanta are working diligently to minimize the radiation dose for every scan.

Children's Heatlhcare of Atlanta is a not-for-profit pediatric facility comprised of three main hospital campuses: Children's at Scottish Rite (250 beds), Children's at Egleston (250 beds), and Children's at Hughes Spalding (20 beds); and numerous neighborhood locations. Three of the facilities perform a total of approximately 16,000 CT scans annually. Historically, work to reduce CT radiation dose has focused on the revision of all CT protocols to minimize radiation dose while still providing diagnostic image quality. The creation of weight based protocols has greatly reduced dose to young patients; however, further work regarding best practices were initiated in 2010 to further protect the pediatric patients at Children's Healthcare of Atlanta.

Several reports cite the radiation dose reduction benefits of using bismuth shielding for pediatric patients undergoing multidetector CT.[1,2] There is no data, however, on what the percent of reduction is because it is difficult to measure with standard dosimeters. Experimental and clinical data show bismuth breast and thyroid shields decrease radiation dose to sensitive areas without qualitative or quantitative changes in image quality.[1,2] Based on this data, Children's Healthcare of Atlanta implemented the use of bismuth shields in all patients undergoing CT examinations. Implementation of this shielding program included:

- Staff training including a review of literature, instruction on the proper placement of each bismuth shield (breast and thyroid), and discussion of infection control precautions including the use of shield covers.
- Purchase of bismuth breast and thyroid shields ensuring quantity was ordered to fully support the volume of patients treated by the CT program.
- Ongoing review of all images to ensure image quality was not compromised by bismuth shielding.

- Development of parental education regarding the use of bismuth shielding in young patients.
- Cost analysis summarizing the increase in operating costs to ensure proper budgeting for bismuth shield use in the future.

Implementation of Bismuth Shielding

Staff education regarding the use of bismuth shielding was key to the success of this program. Staff must be able to verbalize the benefits of bismuth shield use. Their understanding of the benefits will ultimately assist in their support of shield use in the CT department. After all, the use of bismuth shields can be looked at by staff as just one more step in an already complex patient preparation process for CT. Staff's ability to verbalize the benefits and understand the importance of shield use can ultimately allow the technologists to have a vested interest in further protecting patients from radiation exposure. Staff training included didactic education in staff meetings that focused on the presentation of research supporting the use of bismuth shields. The staff received all articles referenced in training for full review. Following didactic training, all staff was shown how to use the shields during scanning and trainers ensured that staff were able to verbalize the importance of using bismuth shields with young patients. This demonstration focused on placement of the shields for optimal protection. Bismuth shields must be applied to the patient after the initial scout images have been taken and not before. This is necessary with the automatic exposure controls on most modern CT scanners. If placed prior to the scouts, then the automatic controls will increase the technique thinking that it needs to scan through additional thickness. Repeat rate did not increase by using this new practice.

Bismuth shields were purchased in January 2010 and, after staff education, these shields were implemented in the department on February 10, 2010 (Figure 1).

Figure 1 • Patient with breast bismuth shield.

Fifteen breast shields and ten thyroid shields were ordered. The breast shields came in six sizes ranging from neonate to adult large. All breast shields were manufactured with one cm foam off-set. The thyroid shields came in just one size (adult). When examining the thyroid shield, it was determined that the bismuth shield was not necessarily manufactured for children since the size of the shield was too large for some of the small patients. Thus, the size of the thyroid shield was modified by staff to fit smaller necks. These modifications were made by cutting down the self-sealing shields with shears (Figure 2). The cost of each shield prohibited the vendor recommended one time use. Therefore, disposable plastic shield covers and plastic Ziploc bags were utilized to cover each shield during use so the shields could be utilized on multiple patients. A new plastic cover was placed on the shield for each patient, thus providing adequate infection control protection (Figure 3).

Figure 2 • Bismuth thyroid shields cut to size to accommodate pediatric patients.

Figure 3 • Bismuth breast shield covered with protective plastic.

Ongoing Review of Image Quality

In order to continually maintain quality, radiologists routinely review images for artifact and noise. In addition, a survey was distributed to all staff radiologists with a sample of random chest CT studies in which breast shields were applied after initial scouts. The survey examined image quality by looking at artifact. The radiologists were then asked to give an opinion on the benefit of bismuth shielding to the pediatric population. A likert scale was used with all survey questions.

The questions regarding overall use of bismuth shielding were:

- The use of bismuth shielding is beneficial to our pediatric population.
  1-Strongly agree
  2-Agree
  3-Neither Agree nor disagree
  4-disagree
  5-Strongly disagree
- The cost of each breast shield is $100 and each thyroid shield is $20. Given the additional cost of bismuth shielding, the cost is worth the benefit to the patient.

  1-Strongly agree
  2-Agree
  3-Neither Agree nor disagree
  4-disagree
  5-Strongly disagree

The final 20 questions provided chest CT images for the radiologist to review. The likert scale responses for each image review were:

0-No artifact
1-Minimal artifact
2-Artifact limited to anterior chest wall
3-Streaks extend into mediastinum or neck
4-Severe artifact hindering interpretation

Eleven radiologists were surveyed regarding the use of bismuth shields, however, only seven surveys were completed (64%). All radiologists agreed that the use of bismuth shielding was beneficial to the pediatric patients (100% either strongly agreed or agreed with the statement), however, only 83% of radiologists felt the cost was worth the benefit of shielding. Most radiologists commented that since the shields were labeled "single use" the cost of the shields would make use impossible to maintain. In regards to image quality, 65% of the radiologists surveyed commented that no artifacts were identified, 23% reported minimal artifacts, 9% reported artifacts limited to the anterior chest wall, and 3% reported streaks extending into the mediastinum or neck (Figure 4). Thus, a significant number of radiologists (88%) felt the overall image quality was not impacted by the use of bismuth shields.

Dose Reduction

Based on current research, the benefit to the patient by reducing dose to the tissues underneath the shield was clearly established. However, the use of the foam offset with breast shields created a concern that the shield may not be as effective as if it were placed directly on the patient. Recent research confirms the effectiveness of dose reduction despite the one centimeter offset in a study that concluded, "Not only is there still an effective reduction in absorbed dose, but that the gap also highly decreased the noise in the CT images."[3]

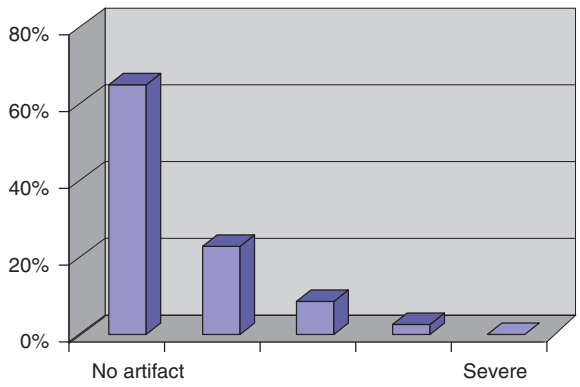

Figure 4 • Artifact caused by bismuth shielding.

Development of Patient and Family Education

Patient education is a very important aspect of treatment. It is the process of providing verbal or written material to the patient and family to improve understanding regarding a treatment or procedure. Communicating the risks and benefits of the procedure is also an important part of patient education. When patient education is done and is successful it can benefit many different parties.

An educational brochure went into production to educate parents on the steps that Children's Healthcare of Atlanta is taking to reduce radiation dose to children during CT scans. The educational flyer discusses dose reduction strategies using ALARA (as low as reasonably achievable) in developing weight based protocols. In addition, it discusses the use of both lead and bismuth shielding; distraction techniques; methods of immobilization; single-phase studies; order review to make sure the correct study is being performed and determination of whether another modality such as MRI or ultrasound could be utilized. Furthermore, similar information regarding dose reduction techniques and procedures is listed on the facility's website. All published material related to Children's Healthcare of Atlanta Radiology includes a reference to its interactive website.

Information regarding radiation dose reduction in CT is also presented to patients and families in the waiting rooms. A display case including information about weight based CT protocols, bismuth and lead shields, and other scanning techniques has been placed in the main radiology waiting room. Patients and families can be directed to this information prior to their scans to learn more about radiation dose in order to ask technologists questions regarding dose saving techniques.

Cost Analysis

A cost-benefit analysis was performed to weigh the total expected costs against the total expected benefits of bismuth shield use in the pediatric population. Bismuth shields are costly ($100.00 per breast shield and $20.00 per thyroid shield), thus purchasing these shields for CT patients can truly impact the operating budget. Furthermore, the bismuth breast and thyroid shields are labeled as per patient use by the manufacturer which can hamper efforts to save money by multi-patient utilization. With the average annual CT volume at 6000 exams, the use of bismuth shields with each patient would cost the organization $390,000. The cost of bismuth shielding is not passed on to the patient population so the cost would be supported by the operating budget of the organization. Currently, with the decline in CT volume reported at many healthcare institutions, this cost may be too high for most hospitals.

Staff education and appropriate follow-up during implementation was so important to achieving support from CT technologists for this new process.

Lessons Learned

Children's Healthcare of Atlanta has had some challenges with the implementation of bismuth shields. One of these has been artifact with the use of the thyroid shields. The thyroid shields are not manufactured with the one centimeter off-set like the breast shields. So when the thyroid shield is placed directly on the patient it produces significantly more noise, and at times creates a beam-hardening or streak artifact. In reviewing the literature, and in our practice with the breast shields, we have determined that off-setting the thyroid shield with a washcloth would reduce issues with artifact and noise. In addition, when the thyroid shield is placed between the neck and chin, the incidence of beam-hardening artifact is increased. The solution is to try to elevate the chin; however, this isn't always possible with the pediatric population.

The second challenge with the thyroid shield is that it is manufactured in only one size for adults. We have been able to successfully modify the shield's size and have created multiple sizes to fit the patient population. Any pediatric center purchasing these shields must be prepared to customize the thyroid shield for small patients.

Staff education and appropriate follow-up during implementation was so important to achieving support from CT technologists for this new process. Initial training regarding radiation dose and shielding is crucial; however, review of images and processes to ensure all technologists are utilizing the bismuth shields was an important step in implementation. At times, the team identified that technologists were forgetting to use bismuth shields so additional follow up education was tailored to technologists who were not following the new standard. During implementation, a team must never assume a process is fully implemented until data proves it is ingrained into daily staff procedures.

Conclusion

Since CT was introduced about 40 years ago, it has continued to offer high quality images with quick processing times. CT is widely used in medical diagnosis and is the gold standard for many patients including trauma and oncology cases. As the use of CT grew, so did the concern regarding radiation dose exposure specifically in young patients who are more susceptible to radiation's effects. Historically, radiation dose reduction has been focused on the scanning protocol including the development of weight based protocols in children. However, the use of bismuth shielding has shown promise in radiation dose reduction to specific areas of the body.

References

[1]Coursey C, Frush DP, Yoshizumi T, Toncheva G, Nguyen G, Greenberg SB. Pediatric chest MDCT using tube current modification: effects on radiation dose with breast shielding. *Pediatric Imaging*. 2008;190:54–61.

[2]Fricke BL, Donnelly LF, Frush DP, Yoshizumi T, Varchena V, Poe SA, Lucaya J. In-plane bismuth breast shields for pediatric CT: effects on radiation dose and image quality using

experimental and clinical data. *AJR Am J Roentgenol*. 2003 Feb;180(2):407–11.

[3]Lee K, Lee W, Lee J, Lee B, Oh G. Dose reduction and image quality assessment in MDCT using AEC (D-DOM & Z-DOM) and in-plane bismuth shielding. *Radiat Prot Dosimetry*. 2010 Sep;141(2):162–7. Epub 2010 May 28.

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