Multidetector CT Findings in the Abdomen and Pelvis after Damage Control Surgery for Acute Traumatic Injuries


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Jeffrey S. Klein, MD  This is Jeff Klein, Editor of RadioGraphics and today I am pleased to have with us Dr. Lauren Alexander from the Department of Radiology at the Mayo Clinic in Jacksonville, Florida; and Dr. Tarek Hanna from The Department of Radiology and Imaging Sciences at the Emory University School of Medicine in Atlanta, Georgia who are the authors of one of our featured papers in the current July, 2019 issue of RadioGraphics. Their paper is entitled “Multidetector Computed Tomography Findings in the Abdomen and Pelvis after Damage Control Surgery for Acute Traumatic Injuries.” Dr. Alexander and Hanna, thank you for joining us for today’s podcast.

Lauren F. Alexander, MD  Thank you.

Tarek Hanna, MD  Thank you very much.

JSK  So Dr. Alexander your paper is a really important one and it’s derived from the experience with CT following damage control surgery from four different institutions. Can you give us a sense of what you found when you were looking at literature on this particular topic as it relates to imaging and why your group felt compelled to develop the exhibit from which this particular article is derived?

LFA  Thank you. My interest in this topic has grown from my cumulative experience as a resident and then a faculty myself at three different institutions at different level one trauma centers. All of these sites we found it really challenging to interpret this particular type of a case especially when we didn’t have the time or the opportunity to discuss with our surgeons what the patient underwent in the OR, why they went to the OR. And so we found that even though trauma injury crosses multiple specialty areas and multiple types of surgery, there are some common themes which can arise and that we’ve reviewed in this paper. The literature for this particular role of imaging in patients after emergency surgery is small, but it is increasing and at least ten to thirty percent of patients may go to surgery before they get a pre-procedure study. The additional injuries that we have seen in the research that can be identified with early post-operative imaging can then affect further care so we think it’s important to image these patients seen after surgery. And what our group really hopes to find is that by focusing on these common findings and the challenges of interpreting these examinations, we can encourage future research for this particular question and also help radiologists when they’re interpreting these studies feel more comfortable with the typical findings in this population.

JSK Terrific, thanks so much. So Dr. Hanna let’s move to you. Following an introduction that provides some of the perspective on the scope of this issue at least in the United States, the paper delves into the initial assessment and management of these traumatized patients. You discuss and in Figure 1 you illustrate the so-called vicious bloody cycle which is described in the surgical literature and then you detail the use of damage control surgery or DCS for short which is serious of procedures and resuscitation steps that are employed to try to stabilize these patients. Table 1 lists the indications for damage control surgery which we can now show to our audience. Can you tell our audience what DCS actually entails?

TH  Sure, yeah. So as you implied, I think it’s most accurate to conceptualize DCS not as a single surgery, but rather as a series of steps intended to preserve a severely traumatized patient’s life. About ten percent of trauma patients are candidates for DCS and in these patients, patients are taken immediately to the operating room in order to control hemorrhage and stabilize life-threatening injuries. For bleeding this involves packing laparotomy pads, cauterizing pressure, even ligation or bypass for bleeding that’s not being controlled in other ways. Now in the case of peritoneal DCS, DCS can actually occur in the thorax of the retroperitoneum and other areas of the body. The body is interrogated, devitalized bowel segments are excised, then ileostomies or colostomies are created as needed. Now biliary pancreatic and urine leaks if they’re present are diverted or drained rather than repaired, so we minimize surgical time and then get the patient as quickly as possible to the ICU and there are three core things that happen in the ICU. You want to rewarm the patient to raise core body temperature. We want to correct an acidosis which occurs in these severely traumatized patients and lower lactate; and then we want to give the patient transfusions in order to raise hemoglobin hematocrit and keep up perfusion. And then the surgeons, the trauma team, assembles a team of subspecialists if needed, urologists, vascular surgeons, and then takes the patient back to the operating room 48 to 72 hours later to definitively surgically treat the patient. This whole series of steps I think can be brought up as DCS all with the intention of having these patients get a better chance of recovery.

JSK  Terrific, thanks. So Lauren, obviously the main purpose of this review is to make radiologists aware of
what to consider when they’re performing and interpreting the CT studies in this particular patient group. Can you talk about the timing of CT studies in this setting and we’ll also review the various options regarding CT protocols for these patients. We’ll put up Table 2 which details your split bolus trauma CT protocol that’s described in the paper.

**LFA** Okay. Since these patients have undergone emergency surgery, timing of this postoperative CT must take into account their ability to travel to the scanner, but ideally early imaging as close as possible to surgical time is optimal. We want to identify any additional injuries that may need further intervention. For example, one retrospective study found that patients imaged after DCS at least eight percent had active bleeding or pseudoaneurysm in the liver and then went on to angio intervention. So in general the CT should cover the chest, abdomen, and pelvis with imaging of the head and neck if indicated clinically, and we really like dual phase technique for the initial studies so we get atrial phase to evaluate for any active bleeding or pseudoaneurysm as well as the venous phase so we can adequately grade solid organ injury. By using the split bolus technique we find that this contrast timing allows us to achieve those two separate phases by splitting the dose of contrast, but attaining the acquisition in one single CT exposure so we can somewhat lower the radiation dose in this patient population that will likely undergo multiple CT examinations during that hospitalization. Additionally we may give oral or rectal or bladder contrast depending on specific patient needs. We find it’s very easy to give rectal and intratesticular contrast on the CT table when they come down. Oral contrast can be more challenging because we need some time for bowel transit. So that’s usually eliminated often in our patients unless they really specifically have a concern for a bowel leak and can take the time to wait for the contrast to pass. Occasionally we will add a delay urographic phase if there is concern for a renal pelvis or urothelial injury to look for leaks there.

**JSK** Right. Terrific, thanks so much. So Dr. Hanna moving on to the main focus of the paper, let’s discuss the spectrum of expected CT findings post DCS. This section begins by describing the appearance of laparotomy pads used to temporize bleeding and the altered anatomy commonly encountered on imaging. After reviewing temporary abdominal wall closure devises, the paper illustrates foreign bodies related to the traumatic event itself. Can we discuss this subject and we’ll play a movie too here which is a movie that comes from Figure 7 in the paper.

**TH** Okay sure. I think that when tackling these complex cases following damage control surgery two things are important to keep in mind. First I’d like to review the preoperative imaging that’s obtained usually these patients have chest and pelvic radiographs or chest and abdominal radiographs. And what that allows us as radiologists to do is to establish what foreign bodies were present following trauma but prior to surgery and the distribution of those foreign bodies trying to reconstruct the ballistic tract if possible, and then secondarily looking at the clinical notes. The initial trauma presentation note so we know where the entrance and exit wounds in the case of penetrating trauma were and then looking at the damage control surgery note itself. See where DCS surgery was performed, what compartments were violated, then what the surgeons discovered during their surgery. Now going to movie two, we can see that this patient has an open abdomen and again that’s expected in the post DCS setting with a temporary abdominal closure devise since these patients usually return to the OR within 48 to 72 hours. You can clearly see air within the abdomen again postsurgical in origin. And then we can see multiple metallic foreign bodies in this patient who was status-post ballistic injury. And those of us who work with patients who are status-post ballistic injury know that bullets often fragment and then spread along multiple ballistic trajectories and in this patient we can see that their peritoneal, retroperitoneal, and intraspinal ballistic tracts and this is important in the post DCS patient. So if this patient has only undergone peritoneal DSC, the surgeons may not know about the retroperitoneal foreign bodies, retroperitoneal injuries, and then they almost certainly don’t know the location of the intraspinal injury or any osseous injuries. So we want to use this post DSC imaging to add to what the surgeons discovered during surgery.

**JSK** Terrific. Thanks so much. Dr. Alexander, the findings in relatively unstable patients scanned in the resuscitation period are important for radiologists to recognize. Let’s discuss the CT hypoperfusion complex as it relates to the vasculature and the intraperitoneal and retroperitoneal viscera and we’ll review Figure 13 here which illustrates this complex in a post splenectomy patient.

**LFA** The CT findings that are associated with hypovolemia can involve multiple organs such as variable enhancement and there’s due to be alterations in perfusion. A single finding in isolation is not specific for hypovolemia, but when two or more of the findings are present, we really should be considering volume status and an underlying cause and carefully evaluate the patient for any sources of active bleeding. The case in Figure 13 illustrates several of these findings. We can see the hyper-enhancing adrenal glands bilaterally and indicated by the circles as well as diffuse thick walled and hyper-enhancing bowel that is associated with the shock state. Other findings to look for would be heterogeneous liver enhancement due to the dual venous anarchical perfusion. The spleen when present tend to be hypo enhancing, same with the kidneys can be hyper enhancing. On the vascular side we may see flattening or a narrowed appearance of the IBC, fluid specifically around the IBC without evidence of injury and similar narrowing of the aorta.

**JSK** Great, thanks so much. Dr. Hanna, regarding imaging for ongoing hemorrhage, you discuss the use of dual phase CT protocol particularly for detecting hepatic and splenic bleeding. One of the less common sites of hemorrhage following DCS is the mesentery which you show in movie six which is Figure 16 in the article. Can we look at this and have you discuss the findings in this particular case?
TH Sure. So in this movie I’d like to draw your attention to the right paramedian mesentery just above the level of the umbilicus and just to the right of the SMV. You can see this patient is status post DSC. We can see packing in place particularly in the right upper quadrant. And I think in appreciate this right paramedian mesenteric hematoma it’s closely associated with loops of bowel and then as it scrolls through you can see these indistinct regions of high density. So this is active contrast extrapolation so called contained vascular injury on this portal venous phase coronal examination. And so this patient has ongoing mesenteric bleeding. We know that mesenteric hematomas and mesenteric bleedings are associated with and predictive of bowel injury. So the two things we want to notify our surgical team of is obviously the continuing mesenteric hemorrhage in this patient, and also if they did not discover any bowel injury during DSC, we want to alert them to look closely in that segment of bowel for injury.

JSK Great, thanks. So the next sections of the paper review retroperitoneal injuries and intraabdominal hypertension and abdominal compartment syndrome. And then the paper moves into the diagnostic challenges that are encountered including the detection of clinically occult injuries that are seen and a significant percentage of these patients after DSC and the use of the American Association for the Surgery of Trauma Organ Injury Scale. The paper then discusses the detection and management of complications related to the injury or to the DCS itself, which as you state in the paper can be difficult as you typically don’t have preoperative imaging for comparison purposes and the postoperative changes can make the evaluation of projectile tracts in particular rather difficult. Lauren, the final section of the paper discusses artifacts on CT as they relate to a variety of factors. Can you discuss those that you commonly encounter on these studies, and then we’ll take a look at Figure 22 which shows a case of pseudo fractures that are related to patient movement during the acquisition of the scan?

LFA Our technologists work really hard to remove as many external artifacts as they can safely, but these patients do often have multiple monitoring bleeds on the surface. And then we also are gonna have our pre-surgical post traumatic foreign bodies that can be metallic creating artifact. And then our surgical devises that are in place in various parts of the abdomen and pelvis such as the laparotomy pads that are gonna have gas bubbles and densities that will create artifacts potentially as well. Being familiar with the typical appearance of the these foreign bodies and the effects they can have on your scan, can make it a bit – I don’t want to say easier, but at least accessible and familiar with these devises and know that they’re not an injury they are an expected foreign body. And we can use as many bells and whistles as we have available in our particular PAC system to window and level, do you multi planar reformats on the fly sometimes can help see through and around these devises. Particularly in this case the step off artifact for motion that you see on the sagittal image of the sternum when we look at the localizer image, we can be confident that yeah there’s no external fracture there, this is just a typical appearance of a motion artifact in the bone.

JSK Sure, thanks. So doctors Alexander and Hanna, I want to thank you for taking the time today to discuss your paper on the multidetector computed tomography findings in the abdomen and pelvis after damage control surgery for acute traumatic injuries which can be found in the current July, 2019 issue of RadioGraphics. I’ll also point out to our readers, be sure to read the accompanying commentary by Dr. Christina LeBedis from Boston University Medical Center which can be found in the current issue immediately following this article. Lauren and Tarek, thanks so much for taking the time today to discuss your article.

LFA Thank you.

TH Thank you very much.