Mesenteric ischemia, intra-abdominal hypertension, and the abdominal compartment syndrome

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In the Winter 2015 issue of *Plastic Surgery*, Sun et al (1), in their report "Ischemic bowel as a late sequela of abdominal compartment syndrome secondary to severe burn injury", reported a case of a presumably ischemic complication likely attributable to multiple episodes of the secondary and recurrent abdominal compartment syndrome (ACS) in a young child. This report and the author's discussion is an important and timely addition to the admittedly sparse literature concerning mesenteric ischemia, intra-abdominal hypertension (IAH) and ACS, particularly in the burn population, raising many points that warrant further consideration and potentially directing future research efforts.

As the authors explain, it has long been assumed that mesenteric ischemia is a critical concern with pathologically raised intra-abdominal pressure, one that facilitates bacterial translocation and exacerbates the biomediator burden driving multisystem organ failure (2). In animals, even low levels of IAH have been shown to greatly diminish mucosal perfusion, disrupt the gut mucosa, alter the protein expression of tight junctions, increase the mucosal permeability and to drive endotoxin systemically (3-5). This appears to be a compelling argument, except that it remains to be proven in humans. The best data remains the experience of Ivatury et al (6), who found that after severe penetrating abdominal trauma, the majority of those with severe grade III IAH (>25 mmHg), had acidotic gut mucosal pH (7.10±0.2) even without exhibiting the classic signs of overt ACS. In those selected for decompression, the pH subsequently improved and none developed ACS. Two patients who had no sustained response in pH and IAH after abdominal decompression progressed to manifest ACS and multiple organ dysfunction syndrome, and subsequently died. Overall, multiple organ dysfunction syndrome points and death were greater in those with IAH than those without. In the case presented by Sun et al (1), it is noteworthy that the sequelae of the likely ischemic small bowel injury became apparent long after the presumed ischemic injury. This may have related to subclinical mucosal injury that healed with scar and no full-thickness perforation. Mohan et al (7) described that, in a porcine model in which postoperative IAH was induced and then relieved, there was small bowel but not large bowel necrosis. Clearly, however, more study is required to understand the full implications for therapy.

As the authors also point out, however, although the gut is assumed to be central to IAH/ACS, better human data simply are not available. Many authors share this view and, as such, the terms 'acute bowel injury' and 'acute intestinal distress syndrome' have been coined (8). The delayed appreciation of these gut-related events may relate to the dramatic clinical events of the overt ACS, with respiratory, cardiovascular and renal failure being obvious and dominating the clinical picture. These overt cases, however, are becoming significantly fewer in contemporary trauma/critical care, attributed largely to radical changes in resuscitation strategies that emphasize restricted crystalloid balanced blood and plasma-based strategies (9,10). This remarkable success in nearly eradicating the ACS has prompted the former World Society of the Abdominal Compartment Syndrome to rebrand as the

World Society of the Abdominal Compartment, emphasizing a new emphasis on trying to understand the more complicated role of IAH in critical illness/injury, and to focus on the study and care of the entire abdominal compartment rather than a single syndrome. Thus, any data and discussion of the more subtle aspects of IAH, such as its role in gut disorders, are greatly encouraged.

Regardless of the name of the professional society, or institution, there remains tremendous work still to be done in understanding IAH/ACS in both burns and the pediatric patient. In this particular case report, the child underwent standard resuscitation with crystalloid fluid. There is suggestive nonrandomized evidence that hypertonic fluids may reduce the risk for secondary ACS with lower fluid load in burn shock patients (11). However, more study is needed because large-volume crystalloid resuscitation remains the most common approach to fluid resuscitation of burn shock. Judiciousness is essential, because modern burn resuscitation frequently grossly exceeds volumes predicted by the Parkland formula (12,13), and other formulas. Thus, it may not be surprising that it remains accepted – if not expected – that nearly all patients with large burns (>60% to 70% body surface area), especially with smoke inhalation, will develop severe IAH/ACS (12,14,15). Given this expected risk, we believe it is mandatory, not elective, to measure IAP in all severe burns, regardless of the physical examination of the abdomen, because clinical examination has proven inaccurate (16,17).

Another important point to emphasize is that the patient in question was clearly a young child, in whom the standard ranges for IAH/ACS based on adult populations are not applicable. The recent guidelines from the Abdominal Compartment Society state that ACS in children is defined as a sustained elevation in IAP >10 mmHg associated with new or worsening organ dysfunction that can be attributed to elevated IAP (18). Thus, this child's ACS was of longer duration and severity than may have been appreciated. It is unstated whether IAPs were measured to document resolution of the first episode of secondary ACS, although there was clear resolution and return to normal IAP after the use of percutaneous drainage for the two subsequent episodes of recurrent ACS. If medical IAH/ACS management techniques fail to resolve IAH/ACS, it is absolutely recommended to proceed to percutaneous drainage therapies because this may often be quite effective (15,18). The abdominal compliance will typically be a steep part of the pressure/volume curve such that small reductions in volume yield marked improvements in pressure (19). However, vigilance must be maintained such that after successful treatment of IAH, satisfactory levels of IAP are maintained at all times in the management of the critically ill/injured, which simply means measuring IAP levels in patients at risk (20). Another admonition, however, is that we would suggest that bedside ultrasound can greatly increase the safety and effectiveness of percutaneous drainage and we would assume all clinicians caring for the critically ill should be familiar with these techniques. It will never be known whether the eventual stricture causing the small bowel obstruction was related to a potential injury at blind paracentesis, a criticism that can now be completely mitigated by using real-time ultrasound guidance (21).

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Finally, a balanced discussion should disclose that the evidence for all these suggestions and recommendations is low level and more attention, study and awareness is required of all caring for the critically ill/injured with the goal that future evidence-based consensus guidelines will need to be continually revised to reflect ever accumulating high-level scientific evidence. Thus, all with interest in the study and management of diseases and conditions of and within the abdominal compartment are encouraged to join and study with the renamed Abdominal Compartment Society (www.wsacs.org).

POINTS OF EMPHASIS

- Normal IAP in children is not the same as adults. A best working consensus of IAH/ACS in children considers that ACS in children is defined as a sustained elevation in IAP >10 mmHg associated with new or worsening organ dysfunction that can be attributed to elevated IAP.
- Secondary IAH/ACS in burn patients generally occurs within 48 h of thermal injury while recurrent IAH/ACS may occur anytime thereafter, typically associated with septic episodes or aggressive burn excision.
- The gut is profoundly adversely influenced by IAH and can be expected to be severely affected by ACS, even if the clinical effects are not obvious and overshadowed by more dramatic dysfunctions in other organ systems.
- Severe IAH and/or ACS may be expected with large body surface area burns when standard fluid resuscitation practices are utilized. Thus, IAP monitoring should be mandatory rather than elective.
- Treatment of IAH/ACS may be conducted using escalating therapies recommended by the Abdominal Compartment Society (formally the World Society of the Abdominal Compartment Syndrome [18]).

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