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Intra-abdominal hypertension and the abdominal compartment syndrome: updated consensus definitions and clinical practice guidelines from the World Society of the Abdominal Compartment Syndrome

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Abstract *Purpose:* To update the World Society of the Abdominal Compartment Syndrome (WSACS) consensus definitions and management statements relating to intra-abdominal hypertension (IAH) and the abdominal compartment syndrome (ACS). *Methods:* We conducted systematic or structured reviews to identify relevant studies relating to IAH or ACS. Updated consensus definitions and management statements were then derived using a modified Delphi method and the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) guidelines, respectively. Quality of evidence was graded from high (A) to very low (D) and management statements from strong RECOMMENDATIONS (desirable effects clearly outweigh potential undesirable ones) to weaker SUGGESTIONS (potential risks and benefits of the intervention are less clear). *Results:* In addition to reviewing the consensus definitions proposed in 2006, the WSACS defined the open abdomen, lateralization of the abdominal musculature, polycompartment syndrome, and abdominal compliance, and proposed an open abdomen classification system. RECOMMENDATIONS included intra-abdominal pressure (IAP) measurement, avoidance of sustained IAH, protocolized IAP monitoring and management, decompressive laparotomy for overt ACS, and negative pressure wound therapy and efforts to achieve same-hospital-stay fascial closure among patients with an open abdomen. SUGGESTIONS included use of medical therapies and percutaneous catheter drainage for treatment of IAH/ACS, considering the association between body position and IAP, attempts to avoid a positive fluid balance after initial patient resuscitation, use of enhanced ratios of plasma to red blood cells and prophylactic open abdominal strategies, and avoidance of routine early biologic mesh use among patients with open abdominal wounds. NO RECOMMENDATIONS were possible regarding monitoring of abdominal perfusion pressure or the use of diuretics, renal replacement therapies, albumin, or acute component-parts separation. *Conclusion:* Although IAH and ACS are common and frequently associated with poor outcomes, the overall quality of evidence available to guide development of RECOMMENDATIONS was generally low. Appropriately designed intervention trials are urgently needed for patients with IAH and ACS.

Keywords Intra-abdominal hypertension · Abdominal compartment syndrome · Critical care · Grading of Recommendations, Assessment, Development, and Evaluation · Evidence-based medicine · World Society of the Abdominal Compartment Syndrome

Introduction

Increased attention to intra-abdominal pressure (IAP), along with changes in the clinical management of critically ill or injured patients, have led to an exponential growth in research relating to intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS) in recent years [1, 2]. Milestones have included the incorporation of the World Society of the Abdominal Compartment Syndrome (WSACS; www.WSACS.org), and the Society's publication of IAH and ACS expert consensus definitions in 2006 [3, 4], clinical practice guidelines in 2007 [5], and recommendations for research in 2009 [6]. Changes in the management of critically ill surgical and/or medical patients have included increased use of damage control surgery and resuscitation [7–11], percutaneous catheter-based and other minimally invasive therapies, early goal-directed therapy for severe sepsis [12, 13], and a heightened appreciation of the risks of over-resuscitation [14, 15]. In light of such developments, the WSACS reviewed the literature and updated their proposed 2006 consensus definitions and 2007 management statements. The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) system for clinical practice guideline developers was used to provide consistency in identifying and rating the quality of available evidence and the strength of management suggestions and recommendations [16–22]. Although the results of our update is reported concisely here, interested readers may refer to the parent report for details (Supplement 1; see electronic supplementary material, ESM).

Methods

Evaluation of existing 2006 consensus definitions and risk factors

In concordance with the levels of agreement appropriate for consensus [19], all 2006 expert consensus definitions for which more than 80 % of the members voted to accept "as is" were retained, while all those with less than 50 % acceptance were rejected. Definitions with only 50–80 % agreement were revised through ongoing discussion until complete consensus was obtained. Where extensive discussion among subspecialists or other experts was required, special sub-committees were created, including a dedicated Pediatric Guidelines Sub-Committee who reviewed the adult guidelines to determine their generalizability to pediatrics. We also searched the literature to determine which IAH or ACS risk factors proposed in 2006 are now supported by evidence and developed a consensus open abdomen classification system. Further details are presented in Supplement 2 (see ESM).

Development of consensus management statements

We followed GRADE recommendations for guideline developers in order to generate management statements related to IAH/ACS [18]. Using this approach, guidelines committee members first developed structured clinical questions and then defined patient-important outcomes with the assistance of an independent GRADE methodological advisor (R.J.). Questions were based on polling of the WSACS Executive to redundancy and were formulated according to the Patient, Intervention, Comparison, Outcome, and study Design (PICO) format [23]. Systematic review teams subsequently conducted systematic or structured/semi-structured reviews and prepared evidence profiles for each of the identified patient-important outcomes as suggested by GRADE [18, 20, 24].

Grading of evidence and development of management statements

After each systematic review team had created their initial evidence profile, formal face-to-face meetings among all guideline committee members were held on two separate days immediately preceding and following the Fifth Scientific Congress of the WSACS in Orlando, FL, USA in August 2011. At the Management Guidelines Meeting, each systematic review team formally presented their search methods and evidence profile. In accordance with GRADE guidelines, they then made recommendations to the panel regarding the direction (for/against/no recommendation) and strength (recommend/suggest) of the proposed statement [16–18, 20, 23–26]. Ultimately, the quality of evidence for each outcome was rated along a four-point ordinal scale in which each evidence grade was symbolized by a letter from D to A: very low (D), low (C), moderate (B), and high (A). Further details are presented in Supplements 3 and 4 (see ESM).

Results

Existing consensus definitions and risk factors

The 2013 WSACS consensus definitions are presented in Table 1. Changes from the previously published 2006 definitions, and the pertinent rationale for such, are outlined in Supplement 5 (see ESM). Risk Factors for IAH and ACS are shown in Table 2 [2, 4, 7, 27–42].

Classification of the open abdomen

Critical complications which should be considered in managing the open abdomen include [43]: (1) fixation of the

Table 1 Final 2013 consensus definitions of the World Society of the Abdominal Compartment Syndrome

No.	Definition
Retained definitions from the original 2006 consensus statements [13]	
1.	IAP is the steady-state pressure concealed within the abdominal cavity
2.	The reference standard for intermittent IAP measurements is via the bladder with a maximal instillation volume of 25 mL of sterile saline
3.	IAP should be expressed in mmHg and measured at end-expiration in the supine position after ensuring that abdominal muscle contractions are absent and with the transducer zeroed at the level of the midaxillary line
4.	IAP is approximately 5–7 mmHg in critically ill adults
5.	IAH is defined by a sustained or repeated pathological elevation in IAP $\geq$ 12 mmHg
6.	ACS is defined as a sustained IAP > 20 mmHg (with or without an APP < 60 mmHg) that is associated with new organ dysfunction/failure
7.	IAH is graded as follows Grade I, IAP 12–15 mmHg Grade II, IAP 16–20 mmHg Grade III, IAP 21–25 mmHg Grade IV, IAP > 25 mmHg
8.	Primary IAH or ACS is a condition associated with injury or disease in the abdominopelvic region that frequently requires early surgical or interventional radiological intervention
9.	Secondary IAH or ACS refers to conditions that do not originate from the abdominopelvic region
10.	Recurrent IAH or ACS refers to the condition in which IAH or ACS redevelops following previous surgical or medical treatment of primary or secondary IAH or ACS
11.	APP = MAP − IAP
New definitions accepted by the 2013 consensus panel	
12.	A polycompartment syndrome is a condition where two or more anatomical compartments have elevated compartmental pressures
13.	Abdominal compliance is a measure of the ease of abdominal expansion, which is determined by the elasticity of the abdominal wall and diaphragm. It should be expressed as the change in intra-abdominal volume per change in IAP
14.	The open abdomen is one that requires a temporary abdominal closure due to the skin and fascia not being closed after laparotomy
15.	Lateralization of the abdominal wall is the phenomenon where the musculature and fascia of the abdominal wall, most exemplified by the rectus abdominus muscles and their enveloping fascia, move laterally away from the midline with time

ACS abdominal compartment syndrome, *APP* abdominal perfusion pressure, *IAH* intra-abdominal hypertension, *IAP* intra-abdominal pressure, *MAP* mean arterial pressure

Table 2 Risk factors for intra-abdominal hypertension and abdominal compartment syndrome

Risk factor
Diminished abdominal wall compliance
Abdominal surgery [27–29]
Major trauma [27, 30, 31]
Major burns
Prone positioning [32–34]
Increased intra-luminal contents
Gastroparesis/gastric distention/ileus [35]
Ileus
Colonic pseudo-obstruction
Volvulus
Increased intra-abdominal contents
Acute pancreatitis [28]
Distended abdomen
Hemoperitoneum/pneumoperitoneum or intra-peritoneal fluid collections [36]
Intra-abdominal infection/abscess [37]
Intra-abdominal or retroperitoneal tumors
Laparoscopy with excessive insufflation pressures
Liver dysfunction/cirrhosis with ascites [28]
Peritoneal dialysis
Capillary leak/fluid resuscitation
Acidosis [3, 4, 19, 38, 47]
Damage control laparotomy
Hypothermia [30]
Increased APACHE-II or SOFA score [36, 38]
Massive fluid resuscitation or positive fluid balance [2, 27, 29–31, 36, 48]
Polytransfusion [30]
Others/miscellaneous
Age [29]
Bacteremia
Coagulopathy
Increased head of bed angle [40–42]
Massive incisional hernia repair
Mechanical ventilation [35]
Obesity or increased body mass index [2, 28, 48]
PEEP > 10 [28]
Peritonitis
Pneumonia
Sepsis [29, 37]
Shock or hypotension [3, 4, 28, 30, 45]

References are shown if the presented risk factor is supported at least to some degree by primary literature. Those unsupported by primary literature are based on clinical judgment and/or pathophysiological rationale. The patient populations included in these studies included major trauma patients, general intensive care unit patients, severe acute pancreatitis patients, severe extremity injury patients, and surgical intensive care unit patients. Moreover, some of these studies addressed only patients that were mechanically ventilated, whereas others included mixed cohorts of patients with different ventilation statuses

APACHE-II acute physiology and chronic health evaluation-II, *PEEP* positive end expiratory pressure, *SOFA* sequential organ failure assessment

abdominal contents (especially of the viscera to the peritoneal sidewalls) and (2) development of enteroatmospheric fistulae (EAF). To facilitate comparison of patient groups with similar determinants of outcomes and complications, a classification scheme of open abdomen complexity is

Table 3 Classification scheme for the complexity of the open abdomen

1 No fixation	
1A:	Clean, no fixation
1B:	Contaminated, no fixation
1C:	Enteric leak, no fixation
2 Developing fixation	
2A:	Clean, developing fixation
2B:	Contaminated, developing fixation
2C:	Enteric leak, developing fixation
3 Frozen abdomen	
3A:	Clean, frozen abdomen
3B:	Contaminated, frozen abdomen
4 Established enteroatmospheric fistula, frozen abdomen	

This is an update of the original Bjorck [97] classification. Enteric leak describes the situation where there is spillage of enteric contents into the abdomen without established enteric fistula development

presented (Table 3). The rationale for creation of this classification system is outlined in Supplement 6 (see ESM).

Pediatric Guidelines Sub-Committee: definitions

A dedicated pediatric sub-committee evaluated the adult definitions for use among children. A summary of the final accepted pediatric definitions is presented in Table 4. For the four definitions rejected, new definitions were proposed that are specific to pediatric use. The rationale for these definitions is outlined in Supplement 7 (see ESM).

Structured clinical questions and consensus management statements

Consensus management statements are summarized in Table 5. Each of these statements are denoted below to indicate whether they were unchanged from previous guidelines, a new guideline, or revised from previous guidelines [5]. An associated summary of overall management and medical management algorithms are presented in Figs. 1 and 2, respectively. The summary of findings and rationale for each of the following management statements is described in the supporting Supplements (see ESM).

Table 4 Final 2013 adapted pediatric consensus definitions

No.	Definition
Definitions accepted without change from the adult guidelines	
1.	IAP is the steady-state pressure concealed within the abdominal cavity
2.	APP = MAP − IAP
3.	Primary IAH or ACS is a condition associated with injury or disease in the abdominopelvic region that frequently requires early surgical or interventional radiological intervention
4.	Secondary IAH or ACS refers to conditions that do not originate from the abdominopelvic region
5.	IAP should be expressed in mmHg and measured at end-expiration in the supine position after ensuring that abdominal muscle contractions are absent and with the transducer zeroed at the level of the midaxillary line
6.	Recurrent IAH or ACS refers to the condition in which IAH or ACS redevelops following previous surgical or medical treatment of primary or secondary IAH or ACS
7.	A polycompartment syndrome is a condition where two or more anatomical compartments have elevated compartmental pressures
8.	The open abdomen is one that requires a temporary abdominal closure due to the skin and fascia not being closed after laparotomy
9.	Pathophysiological classification of the open abdomen 1A: clean, no fixation 1B: contaminated, no fixation 1C: enteric leak, no fixation 2A: clean, developing fixation 2B: contaminated, developing fixation 2C: enteric leak, developing fixation 3A: clean, frozen abdomen 3B: contaminated, frozen abdomen 4: established enteroatmospheric fistula, frozen abdomen
10.	Abdominal compliance is a measure of the ease of abdominal expansion, which is determined by the elasticity of the abdominal wall and diaphragm. It should be expressed as the change in intra-abdominal volume per change in intra-abdominal pressure
Proposed pediatric specific definitions	
11.	ACS in children is defined as a sustained elevation in IAP of greater than 10 mmHg associated with new or worsening organ dysfunction that can be attributed to elevated IAP
12.	The reference standard for intermittent IAP measurement in children is via the bladder using 1 mL/kg as an instillation volume, with a minimal instillation volume of 3 mL and a maximum installation volume of 25 mL of sterile saline
13.	IAP in critically ill children is approximately 4–10 mmHg
14.	IAH in children is defined by a sustained or repeated pathological elevation in IAP > 10 mmHg

ACS abdominal compartment syndrome, *APP* abdominal perfusion pressure, *IAH* intra-abdominal hypertension, *IAP* intra-abdominal pressure, *MAP* mean arterial pressure

Should we measure IAP? Should we measure it via the bladder? Should we use an IAP measurement protocol? (Supplement 8; see ESM)

As clinical examination is inaccurate for detecting raised IAP, IAH and ACS research and management rely upon accurate serial or continuous IAP measurements [44]. Although there is an increasing number of IAP measurement techniques, trans-bladder measurement remains a commonly used method, and was recommended by the WSACS in 2006 due to its simplicity and low cost [3, 45].

Table 5 Final 2013 WSACS consensus management statements

Recommendations

1. We recommend measuring IAP when any known risk factor for IAH/ACS is present in a critically ill or injured patient [GRADE 1C]
2. Studies should adopt the trans-bladder technique as the standard IAP measurement technique [not GRADED]
3. We recommend use of protocolized monitoring and management of IAP versus not [GRADE 1C]
4. We recommend efforts and/or protocols to avoid sustained IAH as compared to inattention to IAP among critically ill or injured patients [GRADE 1C]
5. We recommend decompressive laparotomy in cases of overt ACS compared to strategies that do not use decompressive laparotomy in critically ill adults with ACS [GRADE 1D]
6. We recommend that among ICU patients with open abdominal wounds, conscious and/or protocolized efforts be made to obtain an early or at least same-hospital-stay abdominal fascial closure [GRADE 1D]
7. We recommend that among critically ill/injured patients with open abdominal wounds, strategies utilizing negative pressure wound therapy should be used versus not [GRADE 1C]

Suggestions

1. We suggest that clinicians ensure that critically ill or injured patients receive optimal pain and anxiety relief [GRADE 2D]
2. We suggest brief trials of neuromuscular blockade as a temporizing measure in the treatment of IAH/ACS [GRADE 2D]
3. We suggest that the potential contribution of body position to elevated IAP be considered among patients with, or at risk of, IAH or ACS [GRADE 2D]
4. We suggest liberal use of enteral decompression with nasogastric or rectal tubes when the stomach or colon are dilated in the presence of IAH/ACS [GRADE 1D]
5. We suggest that neostigmine be used for the treatment of established colonic ileus not responding to other simple measures and associated with IAH [GRADE 2D]
6. We suggest using a protocol to try and avoid a positive cumulative fluid balance in the critically ill or injured patient with, or at risk of, IAH/ACS after the acute resuscitation has been completed and the inciting issues have been addressed [GRADE 2C]
7. We suggest use of an enhanced ratio of plasma/packed red blood cells for resuscitation of massive hemorrhage versus low or no attention to plasma/packed red blood cell ratios [GRADE 2D]
8. We suggest use of PCD to remove fluid (in the setting of obvious intraperitoneal fluid) in those with IAH/ACS when this is technically possible compared to doing nothing [GRADE 2C]. We also suggest using PCD to remove fluid (in the setting of obvious intraperitoneal fluid) in those with IAH/ACS when this is technically possible compared to immediate decompressive laparotomy as this may alleviate the need for decompressive laparotomy [GRADE 2D]
9. We suggest that patients undergoing laparotomy for trauma suffering from physiologic exhaustion be treated with the prophylactic use of the open abdomen versus intraoperative abdominal fascial closure and expectant IAP management [GRADE 2D]
10. We suggest not to routinely utilize the open abdomen for patients with severe intraperitoneal contamination undergoing emergency laparotomy for intra-abdominal sepsis unless IAH is a specific concern [GRADE 2B]
11. We suggest that bioprosthetic meshes should not be routinely used in the early closure of the open abdomen compared to alternative strategies [GRADE 2D]

No recommendations

1. We could make no recommendation regarding use of abdominal perfusion pressure in the resuscitation or management of the critically ill or injured
2. We could make no recommendation regarding use of diuretics to mobilize fluids in hemodynamically stable patients with IAH after the acute resuscitation has been completed and the inciting issues have been addressed
3. We could make no recommendation regarding the use of renal replacement therapies to mobilize fluid in hemodynamically stable patients with IAH after the acute resuscitation has been completed and the inciting issues have been addressed
4. We could make no recommendation regarding the administration of albumin versus not, to mobilize fluid in hemodynamically stable patients with IAH after acute resuscitation has been completed and the inciting issues have been addressed
5. We could make no recommendation regarding the prophylactic use of the open abdomen in non-trauma acute care surgery patients with physiologic exhaustion versus intraoperative abdominal fascial closure and expectant IAP management
6. We could make no recommendation regarding use of an acute component separation technique versus not to facilitate earlier abdominal fascial closure

ACS abdominal compartment syndrome, *IAP* intra-abdominal pressure, *IAH* intra-abdominal hypertension, *PCD* percutaneous catheter drainage

Statement

We RECOMMEND measuring IAP versus not when any known risk factor for IAH/ACS is present in critically ill or injured patients (Unchanged Management Recommendation 1 [GRADE 1C]) (Table 2). We also RECOMMEND that studies of IAH or ACS adopt the trans-bladder technique as a standard IAP measurement technique (Unchanged Management Recommendation 2 [not GRADED]). Finally, we RECOMMEND use of protocolized monitoring and management of IAP versus not (New Management Recommendation 3 [GRADE 1C]).

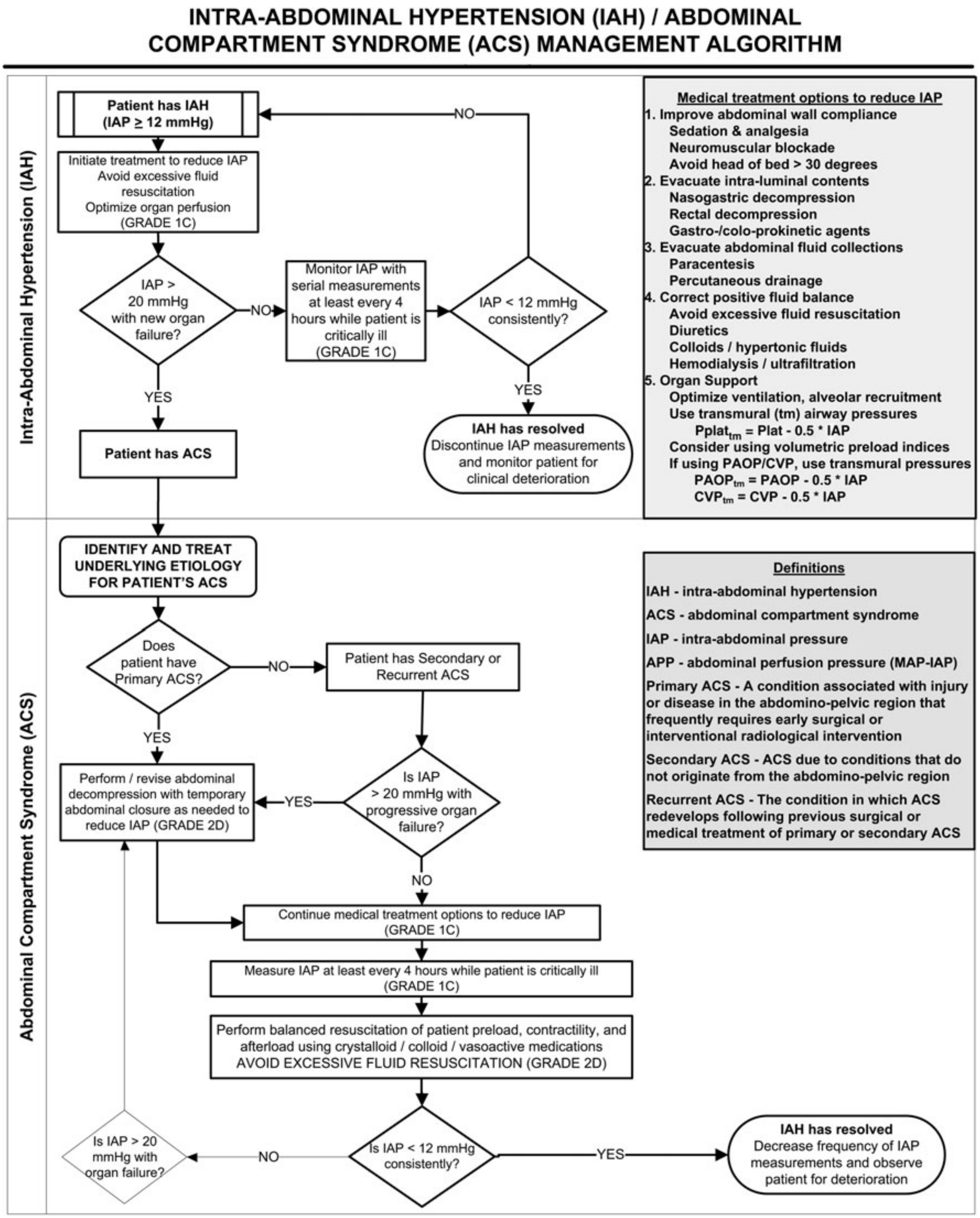

Fig. 1 Updated intra-abdominal hypertension (*IAH*)/abdominal compartment syndrome (*ACS*) management algorithm. *IAP* intra-abdominal pressure

Should we use abdominal perfusion pressure (APP) as a resuscitation endpoint? (Supplement 9; see ESM)

Abdominal perfusion pressure (APP) may be thought of as the abdominal analogue to cerebral perfusion pressure. This measure has previously been suggested as a more accurate predictor of visceral perfusion and a better endpoint for resuscitation than IAP or mean arterial pressure (MAP) alone [3, 46].

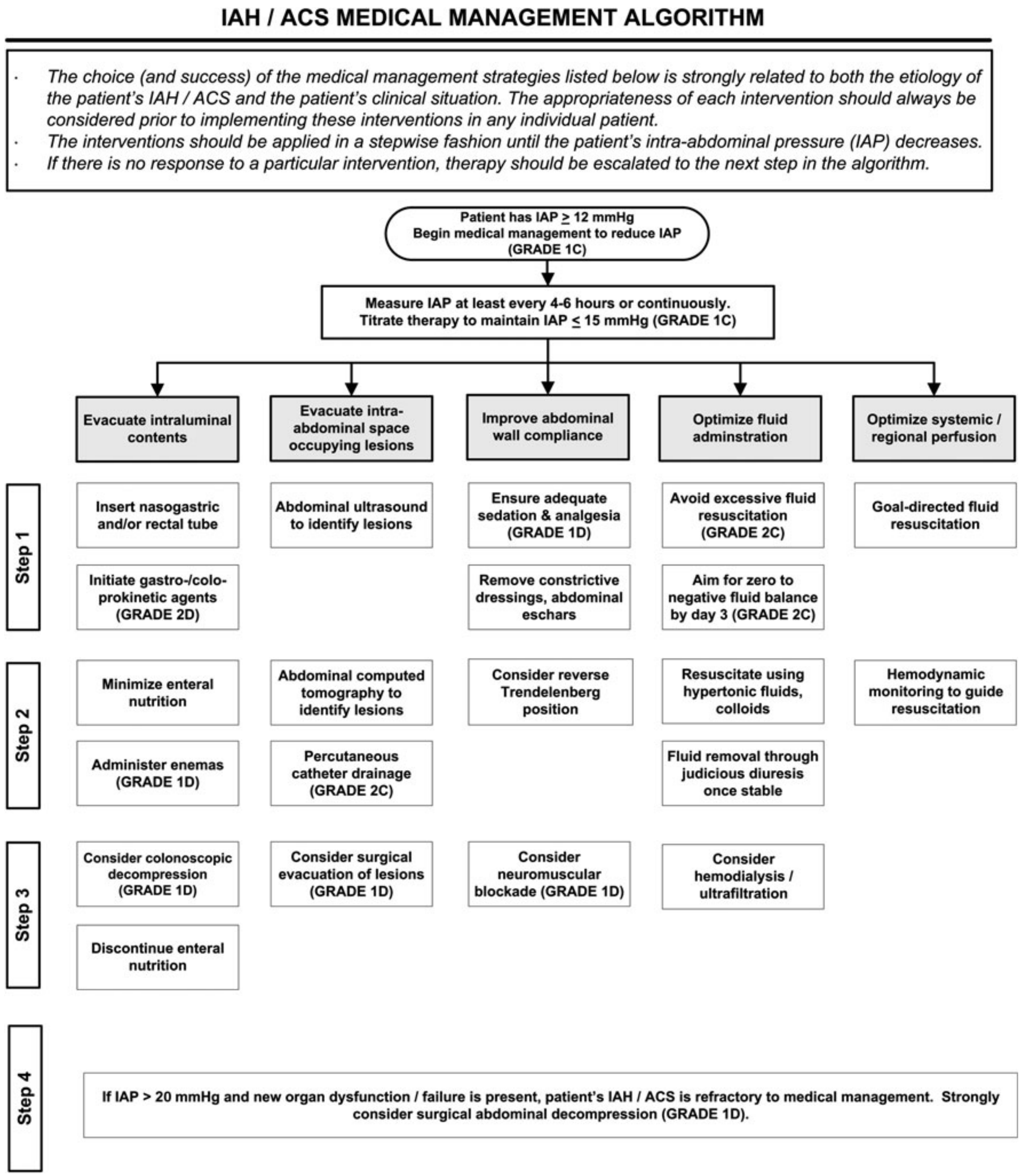

Fig. 2 Updated intra-abdominal hypertension (*IAH*)/abdominal compartment syndrome (*ACS*) medical management algorithm. *IAP* intra-abdominal pressure

Statement

We could make NO RECOMMENDATION regarding use of APP in the resuscitation or management of the critically ill or injured.

Should we treat or prevent IAH? (Supplement 10; see ESM)

Intra-abdominal hypertension (IAH) has consistently been associated with morbidity and mortality in observational studies. However, it remains uncertain as to whether treating or preventing this condition improves patient outcomes.

Statement

We RECOMMEND efforts and/or protocols to avoid sustained IAH as compared to inattention to IAP among critically ill or injured patients (New Management Recommendation 4 [GRADE 1C]).

How should we manage IAH/ACS?

In addition to decompressive laparotomy for ACS, numerous medical and minimally invasive therapies have been proposed or studied that may be beneficial for patients with IAH or ACS [47–49]. Approaches or techniques of potential utility include sedation and analgesia, neuromuscular blockade, body positioning, nasogastric/colonic decompression, promotility agents, diuretics and continuous renal replacement therapies, fluid resuscitation strategies, percutaneous catheter drainage (PCD), and different temporary abdominal closure (TAC) techniques among those requiring an open abdomen [5].

Non-invasive options: sedation and analgesia (Supplement 11; see ESM)

While sedation and analgesia have been incorporated into previous IAH/ACS management algorithms, it remains unclear if they alter outcomes among those with IAH/ACS.

Statement

We SUGGEST that clinicians ensure that critically ill or injured patients receive optimal pain and anxiety relief (Unchanged Management Suggestion 1 [GRADE 2D]).

Neuromuscular blockade (Supplement 12; see ESM)

Through a reduction in abdominal muscular tone and an increase in abdominal compliance, neuromuscular blockade may reduce IAP among those with IAH and/or ACS [50].

Statement

We SUGGEST brief trials of neuromuscular blockade as a temporizing measure in the treatment of IAH (Unchanged Management Suggestion 2 [GRADE 2D]).

Body positioning (Supplement 13; see ESM)

Body positioning may change IAP by altering the zero reference for IAP measurement and/or the external forces on the abdominal cavity [32, 40–42, 51].

Statement

We SUGGEST that the potential contribution of body position to elevated IAP be considered among patients with, or at risk of, IAH or ACS (Unchanged Management Suggestion 3 [GRADE 2D]).

Nasogastric/colonic decompression (Supplement 14; see ESM)

While the routine use of enteric tubes post-operatively has not been associated with benefit after uncomplicated surgery [52, 53], there are anecdotal reports that gastric and colonic distension can induce marked IAH commensurate with ACS [52–56].

Statement

We SUGGEST liberal use of enteral decompression with nasogastric or rectal tubes when the stomach or colon are dilated in the presence of IAH/ACS (New Management Suggestion 4 [GRADE 1D]).

Promotility agents (Supplement 15; see ESM)

Studies have reported that treatment with neostigmine may be effective at inducing colonic decompression among those with colonic pseudo-obstruction [57]. However, no data exist on the effects of pharmacologic promotility therapy on IAP or outcomes among those with IAH/ACS.

Statement

We SUGGEST that neostigmine be used for the treatment of established colonic ileus not responding to other simple measures and associated with IAH (New Management Suggestion 5 [GRADE 2D]).

Should we keep fluid balance neutral or even negative among ICU patients? (Supplement 16; see ESM)

An increased or positive fluid balance has been associated with third space fluid accumulation and organ dysfunction in animal models [58, 59]. However, it remains unknown whether strategies that target a neutral or even negative fluid balance after the initial resuscitation of critically ill patients may be linked with improved clinical outcomes.

Statement

We SUGGEST using a protocol to try to avoid a positive cumulative fluid balance in the critically ill or injured with, or at risk of, IAH/ACS after the acute resuscitation has been completed and the inciting issues have been addressed (New Management Suggestion 6 [GRADE 2C]).

Diuretics (Supplement 17; see ESM)

Although diuretics are commonly used to improve fluid balance among the critically ill, it remains unknown whether they improve outcomes among those with IAH or ACS.

Statement

We could make NO RECOMMENDATION regarding the use of diuretics to mobilize fluids in hemodynamically stable patients with IAH after acute resuscitation has been completed and the inciting issues have been addressed.

Renal replacement therapies (Supplement 18; see ESM)

Renal replacement therapies are increasingly being used to modify fluid balance among the critically ill.

Statement

We could make NO RECOMMENDATION regarding the use of renal replacement therapies to mobilize fluid in hemodynamically stable patients with IAH after acute resuscitation has been completed and the inciting issues have been addressed.

Albumin (Supplement 19; see ESM)

Albumin is frequently administered to critically ill patients in order to expand plasma volume and improve oncotic pressure [60].

Statement

We could make NO RECOMMENDATION regarding the administration of albumin versus not, to mobilize fluid in hemodynamically stable patients with IAH after acute resuscitation has been completed and the inciting issues have been addressed.

Should we use damage control resuscitation? (Supplement 20; see ESM)

Damage control resuscitation is increasingly being used among critically injured patients [7, 8, 10, 61]. This type of resuscitation is characterized by permissive hypotension, limitation of crystalloid intravenous fluids, and delivering higher ratios of plasma and platelets to red blood cells [8].

Statement

We SUGGEST use of an enhanced ratio of plasma/packed red blood cells for resuscitation of massive hemorrhage versus low or no attention to plasma/packed red blood cell ratios (New Management Suggestion 7 [GRADE 2D]).

Minimally-invasive options

If the medical management approaches suggested above do not alleviate IAH, then clinicians will need to consider whether invasive treatments may be necessary.

Should we use PCD? (Supplement 21; see ESM)

Although paracentesis has long been a diagnostic and therapeutic procedure among those without documented IAH, the insertion of an indwelling PCD catheter in an attempt to improve IAP and associated patient-important outcomes among those with IAH/ACS was only first suggested in 2001 [62].

Statement

We SUGGEST use of PCD to remove fluid (in the setting of obvious intra-peritoneal fluid) in those with IAH/ACS when this is technically possible compared to doing nothing (Unchanged Management Suggestion 8 [GRADE 2C]). We also SUGGEST using PCD to remove fluid (in the setting of obvious intraperitoneal fluid) in those with IAH/ACS when this is technically possible compared to immediate decompressive laparotomy, as this may alleviate the need for decompressive laparotomy (Revised Management Suggestion 8 [GRADE 2D]).

Invasive options: should we use decompressive laparotomy for IAH or ACS? (Supplement 22; see ESM)

Decompressive laparotomy historically constituted the standard method to treat severe IAH/ACS and to protect against their development in high risk situations (e.g., following damage control laparotomy for significant intraperitoneal injury) [63, 64]. It has been reported to result in an immediate decrease in IAP and in improvements in organ function [65, 66]. However, decompressive laparotomy is associated with multiple complications and overall reported patient mortality is considerable (up to 50 %), even after decompression [66].

Statement

We RECOMMEND decompressive laparotomy in cases of overt ACS compared to strategies that do not use decompressive laparotomy in critically ill adults with ACS (Unchanged Management Recommendation 5 [GRADE 1D]).

Use of the open abdomen after trauma damage control laparotomy (Supplement 23; see ESM)

The damage control approach to trauma involves an abbreviated resuscitative surgical approach with the primary goal being rapid control of hemorrhage and contamination with restoration of metabolic function at the expense of normal anatomy [8, 63, 64, 67, 68]. Damage control laparotomy is typically a component of a larger damage control approach that includes damage control resuscitation. Although it remains difficult to prove that this approach improves mortality and other outcomes, it has been associated with unexpected patient survival [69, 70].

Statement

We SUGGEST that patients undergoing laparotomy for trauma suffering from physiologic exhaustion be treated with the prophylactic use of the open abdomen versus closure and expectant IAP management (New Management Suggestion 9 [GRADE 2D]).

Damage control laparotomy for non-trauma acute care surgery patients (Supplement 24; see ESM)

While damage control techniques are being used among non-trauma acute care surgery patients (which largely includes emergency general surgery) [70, 71], very little evidence exists to support their use, or to support prophylactic open abdominal management afterwards.

Statement

We could make NO RECOMMENDATION regarding the prophylactic use of the open abdomen in non-trauma acute care surgery patients with physiological exhaustion versus intra-operative abdominal fascial closure and expectant IAP management.

Damage control surgery for patients with intra-abdominal sepsis (Supplement 25; see ESM)

Intra-abdominal sepsis is a particularly devastating and common form of sepsis, which is commonly associated with development of IAH/ACS [72–74].

Statement

We SUGGEST NOT to routinely utilize the open abdomen approach for patients with severe intra-peritoneal contamination undergoing emergency laparotomy for intra-abdominal sepsis unless IAH is a specific concern (New Management Suggestion 10 [GRADE 2B]).

Definitive abdominal closure

While the open abdomen method is a valuable, life-saving tool, the longer the abdomen is open, the greater the potential for morbidity [43, 75–77]. Thus, specific strategies should be utilized from the first laparotomy that consider prevention of visceral adhesions, loss of soft tissue coverage, lateralization of the abdominal musculature and its fascia, malnutrition, and enteric fistulae [43, 76]. The detailed management of the open abdomen is beyond the scope of this document, for which other recent reviews are available [55, 75, 76, 78].

Should we attempt to achieve same-hospital-stay closure of the open abdomen? (Supplement 26; see ESM)

As the inability to achieve primary fascial closure after damage control laparotomy has been associated with increased morbidity and reduced quality of life among critically ill adults, efforts to close the abdominal fascia before discharge could potentially lead to improved outcomes.

Statement

We RECOMMEND that among ICU patients with open abdominal wounds, conscious and/or protocolized efforts be made to obtain an early or at least same-hospital-stay abdominal fascial closure (New Management Recommendation 6 [GRADE 1D]).

Should we preferentially use negative pressure wound therapy (NPWT) for temporary abdominal closure after damage control laparotomy? (Supplement 27; see ESM)

Abdominal NPWT involves applying some degree of suction to an open abdominal wound, using techniques that can be home-made or proprietary. Through use of a visceral drape and constant negative wound pressure, this technique prevents visceral adherence to the anterolateral abdominal wall while maintaining medial fascial traction, which may enhance fascial closure rates among those with an open abdomen [29, 79, 80]. It may also remove fluid and pro-inflammatory cytokines from the peritoneum, which may reduce abdominal third space volume, the systemic inflammatory response, and resultant organ dysfunction [29, 77–79, 81, 82]. However, others have reported concerns over associations between NPWT and recurrent ACS or intestinal or enteroatmospheric fistulae [83, 84], especially among those with limited intra-abdominal fluid available for removal [85].

Statement

We RECOMMEND that among critically ill or injured patients with open abdominal wounds, strategies utilizing negative pressure wound therapy should be used versus not (New Management Recommendation 7 [GRADE 1C]).

Should we use component separation to facilitate early fascial closure of the open abdomen? (Supplement 28; see ESM)

The component separation technique of the abdominal wall musculature may be used to close an already open abdomen, or to avoid an open abdomen without inducing IAH. An acute component separation technique is defined as one performed during the initial hospitalization [78].

Statement

We could make NO RECOMMENDATION regarding use of an acute component separation technique versus not to facilitate early abdominal fascial closure.

Should we use bioprosthethic mesh closures to achieve closure of the open abdomen? (Supplement 29; see ESM)

Advances in tissue recovery and engineering have driven production of a large range of bioprosethic mesh prostheses that provide new options for abdominal wall reconstruction [86–88]. It has been suggested that these meshes can be used to achieve earlier abdominal fascia closure among those with an open abdomen as they may allow for an increased intra-peritoneal domain without enteric fistula formation [89, 90].

Statement

We SUGGEST that bioprosthethic meshes SHOULD NOT be routinely used in the early closure of the open abdomen compared to alternative strategies (New Management Suggestion 11 [GRADE 2D]).

Pediatric IAH and ACS management

The Pediatric Sub-Committee of the WSACS reviewed the main management guidelines in regard to their applicability and suitability for children. They accepted six guidelines as is, rejected none, but could not make recommendations regarding the suitability for children in the remaining six. Their specific opinions are presented in Table 6.

Discussion

In this manuscript, the WSACS presented updated consensus definitions and management statements related to IAH/ACS. It was identified that there were topics for which future review was required, including the most accurate/meaningful reference-standard locations for IAP measurement and the definition of “normal” values of IAP across various patient populations. Moreover, although the Pediatric Sub-Committee reviewed and made recommendations regarding the appropriateness of the updated consensus definitions and management statements for pediatric patients, further work in this area is needed. Similarly, normal values of IAP among obese

Table 6 Opinions of the Pediatric Guidelines Sub-Committee regarding the suitability of the WSACS management recommendations for the care of children

Statements accepted as appropriate

1. Measure IAP when any known risk factor is present in a critically ill or injured patient
2. Protocolized monitoring and management of IAP should be utilized when caring for the critically ill or injured
3. Use percutaneous catheter drainage to remove fluid in those with IAH/ACS when this is technically possible, whether an alternative is doing nothing or decompressive laparotomy
4. Use decompressive laparotomy in cases of overt ACS
5. Negative pressure wound therapy should be utilized to facilitate earlier abdominal fascial closure among those with open abdominal wounds
6. Use a protocol to try to avoid a positive cumulative fluid balance in the critically ill with, or at risk of, IAH

Statements not accepted as appropriate for pediatric care that were not supported for adult care

1. No recommendation was made regarding the use of the abdominal perfusion pressure as a resuscitation endpoint
2. No recommendation was made regarding the use of decompressive laparotomy for patients with severe IAH without formal ACS
3. Biological meshes should not be routinely utilized to facilitate early acute fascial closure
4. No recommendation could be made to utilize the component separation technique to facilitate earlier acute fascial closure among patients with open abdominal wounds
5. Use of enhanced ratios of plasma to packed red blood cells during resuscitation from massive hemorrhage
6. Efforts and/or protocols to obtain early or at least same-hospital-stay fascial closure

ACS abdominal compartment syndrome, *IAP* intra-abdominal pressure, *IAH* intra-abdominal hypertension

and pregnant patients have not yet been adequately defined, and the influence of IAH and ACS in these patients is somewhat poorly understood [91, 92]. Thus, further work among these patient populations is urgently needed. Finally, as overt ACS becomes less common [27], further research must be performed in order to delineate what role IAH without ACS plays in gut ischemia, bacterial translocation, feeding intolerance, anastomotic and wound breakdown, and neurological dysfunction [93–95].

The GRADE system was used to formulate the updated consensus management statements. GRADE is practical in requiring clinical judgements to be made in the context of weighing potential benefits and harms, the burdens of therapy both to the patient and society, and involved costs, with the overall assessment of the quality based on the entire body of evidence, rather than any particular study [96]. Therefore, in the context of making recommendations, the quality of evidence ultimately reflects the degree of confidence that a panel of expert clinicians has in the estimates of effect size [96]. The combined, collective experience is therefore reflected in the RECOMMENDATIONS and SUGGESTIONS, wherein the evidence is reflected in the quality of evidence assessment. With this background, these guidelines should be used as guides for any institution or clinician to initiate their care of the critically ill, at all times evaluating the patients' outcomes ideally in a formal research study or at least in an organized fashion. However, these guidelines should not be used as performance measures or quality assurance criteria to censure any physician or institution.

In utilizing these guidelines, clinicians should be aware that there are ongoing developments in medical knowledge. The panelists made great efforts to review the literature broadly, and to be aware of ongoing research that could influence recommendations. However, the reviewers focused on completed peer-reviewed studies that were available in the public domain. Although some studies could have been missed, we feel it unlikely that the exclusion of the results of these studies would significantly alter our provided recommendations. Nonetheless, it is probable that new knowledge will require future revision of this work. Given the lack of high-quality evidence to base decision-making, this is desirable, and thus users are reminded to use these guidelines in the context of knowing their patients, acting at the bedside, and considering new data as it becomes available.

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Conflicts of interest Andrew W Kirkpatrick has served on an advisory board for Lantheus Medical, Boston, MA, discussing the use of ultrasound contrast media. He received an unrestricted research grant from Kinetic Concepts Incorporated to conduct a prospective randomized trial in open abdomen management. He also received the unrestricted use of a Sonosite NanoMaxx ultrasound machine for research use from the Sonosite Corporation. Jan De Waele has consulted for Smith and Nephew, Ltd., Kinetic Concepts Incorporated, Pfizer and Astra Zenica Corporations. Roman Jaeschke served as a consultant on behalf of the GRADE group to the World Society of the Abdominal Compartment Syndrome. Manu Malbrain served on an Advisory Board for Pulsion Medical Systems, and has consulted for ConvaTec, Kinetic Concepts Incorporated, and Fresenius-Kabi. Martin Bjorck received an unrestricted research grant from Kinetic Concepts Incorporated in 2006. Michael Sugrue has received a speaking Honorarium from Kinetic Concepts Incorporated in 2009 and from Smith and Nephew, Ltd., in 2010–2011. Michael Cheatham has consulted for Kinetic Concepts Incorporated and has provided expert legal testimony concerning IAH and the abdominal compartment syndrome. Rao Ivatury has consulted for Kinetic Concepts Incorporated. Annika Reintam Blaser has consulted for Nestle Health Science. Mark Kaplan served as a consultant for Kinetic Concepts Incorporated. Edward Kimball has received remuneration for lecturing on the Abviser, manufactured by the Abviser Medical Company and receives royalties from its use. No other authors had potential conflicts of interest to report.

Appendix

Additional group authorship: the Pediatric Guidelines Sub-Committee

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