Survey of intensive care physicians on the recognition and management of intra-abdominal hypertension and abdominal compartment syndrome*

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Objective: **To assess current understanding and clinical management of intra-abdominal hypertension and abdominal compartment syndrome among critical care physicians.**

Design: **A ten-question, written survey.**

Setting: **University health sciences center.**

Subjects: **Physician members of the Society of Critical Care Medicine (SCCM).**

Interventions: **The survey was sent to 4,538 SCCM members with a response rate of 35.7% (1622).**

Measurements and Main Results: **Primary training, intensive care unit type, and methods for management of abdominal compartment syndrome were assessed. Surgically trained intensivists managed the highest number of abdominal compartment syndrome cases (47% managed 4–10 cases, 16% managed >10 cases). No cases were seen by 25% of medically trained and pediatric trained intensivists. Respondents agreed that bladder pressures and clinical variables were needed to diagnose abdominal compartment syndrome (70%) vs. bladder pressure (7%) or clinical variables (20%) alone. Two percent of surgical intensivists were unaware of a bladder pressure measurement procedure compared with 24% ($p < .0001$) of pediatric and 23% ($p < .0001$) of medical intensivists. Forty-two percent of respondents believed bladder pressures of 20–27 mm Hg may cause physiologic compromise. However, 25–27% of pediatric, medicine, or anesthesia trained intensivists believed that compromise occurs between 12 and 19 mm Hg compared with 18% of surgeons. No respondent believed that physiologic compromise occurred at <8 mm Hg. Thirty-eight percent of pediatric intensivists believed that physiologic compromise was patient dependent vs. 7–17% from other specialties ($p < .0001$; all comparisons). In managing intra-abdominal hypertension, 33% of pediatric intensivists and 19.6% of medical intensivists would never use decompression laparotomy to treat abdominal compartment syndrome compared with 3.6% of intensivists with surgical training ($p < .0001$; both comparisons).**

Conclusions: **Significant variation across medical training exists in the management of intra-abdominal hypertension and abdominal compartment syndrome. A significant percentage of intensivists may be unaware of current approaches to abdominal compartment syndrome management including monitoring bladder pressures and decompression laparotomy. Future research and education are necessary to establish clear diagnostic criteria and standards for treatment of this relatively common life-threatening disease process. (Crit Care Med 2006; 34:2340–2348)**

KEY WORDS: abdominal compartment syndrome; intra-abdominal pressure; intra-abdominal hypertension; bladder pressure; decompression laparotomy; critical care

The phenomenon of increased intra-abdominal pressures (IAP) and the resultant physiologic compromise were first described in the late 1800s (1, 2). More than a century later, this pathophysiology was recognized as an uncommon but morbid sequelae of abdominal vascular surgery and was termed the "abdominal compartment syndrome" (ACS) (3, 4). This syndrome is presently being seen with an increasing frequency and in a wide variety of critically ill patients. This escalation in occurrence has been closely paralleled by a significant increase in the number of publications related to intra-abdominal hypertension (IAH; defined as IAP >12 mm Hg) and ACS in recent years (Fig. 1) (5).

Significant increases in IAP can be seen in the setting of systemic inflammation with capillary leak resulting in third spacing of fluid, followed by visceral, mesenteric, and retroperitoneal edema, and intra-abdominal free fluid. Ironically, this third spacing is often exacerbated by appropriate and even goal-directed resuscitation (6). Resuscitation in the setting

***See also p. 2494**.

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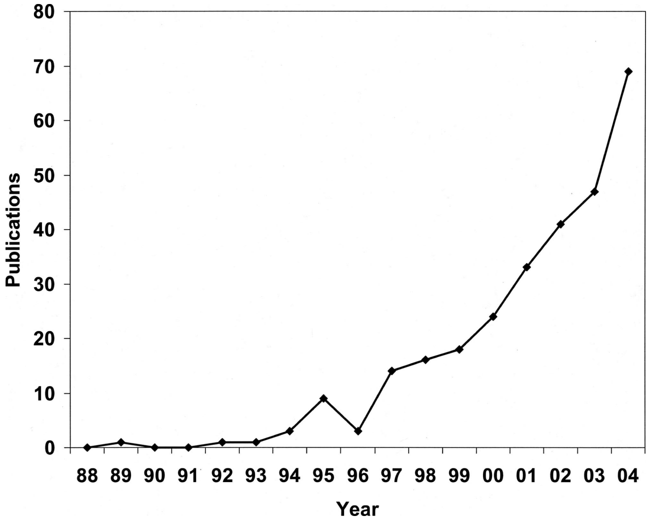

Figure 1. The number of publications listing "abdominal compartment syndrome" or "intra-abdominal hypertension" within the PubMed search criteria (limited by English language in human subjects), by publication years 1988 to 2004.

of systemic inflammatory response syndrome (SIRS) resulting in IAH/ACS has been seen in a wide variety of disease processes including sepsis, pancreatitis, trauma, ischemia reperfusion injury, burns, peritonitis, bowel ischemia, and disseminated intravascular coagulation (4, 7–16). In addition, other clinical conditions, without a significant inflammatory component, can lead to increased IAP including ascites, pregnancy, hemorrhage, pneumoperitoneum, gastric dilation, ileus, bowel obstruction, organomegaly, tumors, repair of large hernias, gastroschisis, and omphaloceles (17–25). Increased IAP leads to compromised blood flow through the gut and a decrease in venous return to the heart. Extreme elevation of IAP can progress to multiple-system organ failure. In fact, ACS has been defined as the "cardiovascular, pulmonary, renal, splanchnic, abdominal wall and intra-cranial disturbances resulting from elevated intra-abdominal pressures" (26).

As the number of patients presenting with systemic inflammation from multiple etiologies increases, the incidence of IAH/ACS will undoubtedly continue to increase as well (27). Malbrain et al. (28) demonstrated that in a 1-day point-prevalence study of 97 patients in 13 separate intensive care units (ICUs) throughout Europe, South America, and Australia, 50.5% of patients had elevated IAP (defined as IAP $\geq$12 mm Hg), and 8.2% of patients had ACS (defined as IAP $\geq$20 mm Hg with failure of one or more organ systems). Although ACS has often been associated with surgical or trauma patients, this study demonstrated that critical IAP ($\geq$20 mm Hg) was actually more common in medical ICU patients than in surgical ICU patients, 10.5% vs. 5%, respectively. Further, these authors demonstrated in a larger population of mixed ICU patients that an IAP $>$12 mm Hg, at any time during an ICU stay, was an independent predictor of a poor outcome (29).

Despite the significant incidence reported by Malbrain et al., and a mortality rate from ACS approaching 70%, there appears to be variable understanding regarding this syndrome among those who care for these patients (26, 30, 31). Recent concerns for this relative lack of knowledge were expressed in an editorial in *Critical Care Medicine* entitled, "Abdominal Compartment Syndrome: A Century Later, Isn't It Time to Pay Attention?" (30). Despite this call to attention, there remains a paucity of evidence-based guidelines to follow in the management of IAH/ACS (31).

The primary goal of this survey was to provide a representative picture of the current awareness of IAH and ACS among intensivists and secondarily to describe the associated diagnostic and therapeutic strategies currently being employed in the clinical management of this pathophysiology. In 2005, a smaller secondary survey was also performed to assess forward-looking trends in the clinical practices of intensivists as a result of the recent increase in the IAH/ACS literature.

MATERIALS AND METHODS

After Institutional Review Board approval, a ten-question written survey was mailed to all physician members of the Society of Critical Care Medicine (SCCM). The survey assessed primary training, type of ICU practice, and methods for the diagnosis and management of ACS. A total of 4,538 surveys were mailed to members with addresses within the United States and U.S. territories in June 2001. The initial number of surveys returned was 1,180 by October 2001. A second mailing was sent in February 2002 to nonrespondents. The combined final return was 1,622 respondents for a calculated response rate of 35.7% calculated September 2002. Data from the completed surveys were entered into Microsoft Excel 2003 and independently reviewed by a second member of the research team. Chi-square analyses and Kruskal-Wallis testing of the data were performed using STATA SE 8.2 (College Station, TX). Bonferroni adjustment was included to compensate for multiple testing with chi-square and Kruskal-Wallis tests. For this statistical correction, p values of $<$.003 (Kruskal-Wallis) and $<$.006 (chi-square) were considered significant.

RESULTS

Respondent Demographics. The first two questions of the survey assessed respondents' workplace and primary training. Of the respondents, 46.8% (n = 757) worked in a combined medical-surgical ICU (MSICU), 33.6% (n = 542) in a surgical intensive care unit (SICU), 12.1% (n = 195) in a medical intensive care unit (MICU), 3.5% (n = 57) in a pediatric intensive care unit (PICU), 2.6% (n = 42) in a burn unit (BICU), and 1.2% (n = 20) in a neurologic intensive care unit (NICU), and 0.2% (n = 3) categorized their primary type of ICU as "other." Of those surveyed, 35.1% (n = 569) had primary training in surgery, 31.5% (n = 510) in medicine, 18.1% (n = 294) in pediatrics, 10.2% (n = 165) in anesthesia, and 0.5% (n = 8) in emergency medicine; 4.6% (n = 74) listed "other" (Table 1).

Frequency and Diagnosis. Question 3 asked respondents to quantify the number of ACS cases seen during the past year. The results ranged from 0 to 75 cases. The results were placed into five groups: 0, 1–3, 4–7, 8–10, and $>$10 cases. Of the respondents, 17.2% (n = 271) saw 0 cases, 38.5% (n = 607) saw 1–3 cases, 26.5% (n = 418) saw 4–7 cases, 9.8% (n = 154) saw 8–10 cases, and 8% (n = 128) saw $>$10 cases in the previous year (Table 1).

Question 4 assessed the way respon-

Table 1. Breakdown of responses to survey questions 1 through 6

Question	Stated Question and Choices	No. of Respondents (%)[a]
1	As an intensivist, what type of intensive care unit do you primarily work in?	
	Medical	195 (12.1)
	Surgical	542 (33.6)
	Combination medical/surgical	757 (46.8)
	Neurologic	20 (1.2)
	Burn	42 (2.6)
	Pediatric	57 (3.5)
	Other	3 (0.2)
2	What is your primary training in?	
	Surgery	569 (35.1)
	Medicine	510 (31.5)
	Emergency medicine	8 (0.5)
	Anesthesia	165 (10.2)
	Pediatric	294 (18.1)
	Other	74 (4.6)
3	Approximately how many cases of abdominal compartment syndrome have you seen in the last year?	
	None	271 (17.2)
	1–3	607 (38.5)
	4–7	418 (26.5)
	8–10	154 (9.8)
	>10	128 (8)
4	How do you diagnose intra-abdominal hypertension?	
	Clinical diagnosis	313 (20)
	Bladder pressures	112 (7.2)
	Combination of clinical diagnosis and bladder pressure	1092 (70)
	Other	45 (2.8)
5	How often do you check bladder pressures?	
	Never (unaware of this procedure)	210 (13.2)
	Never (I don't believe it has clinical correlation)	54 (3.4)
	Seldom	739 (46.5)
	Often	447 (28.1)
	Routinely	124 (7.8)
	Other	15 (1)
6	If you do check bladder pressure, at what pressure do you believe the patient has physiologic compromise?	
	<10 cm H_2O (<7.7 mm Hg)	0
	10–15 cm H_2O (7.7–11.5 mm Hg)	30 (2.3)
	16–25 cm H_2O (11.6–19 mm Hg)	289 (22.6)
	26–35 cm H_2O (20–27 mm Hg)	543 (42.5)
	>35 cm H_2O (>27 mm Hg)	123 (9.6)
	It is patient dependent	226 (17.7)
	Other	68 (5.3)

[a]Percent data based on number of respondents to each question.

dents diagnose IAH, given the choices of clinical diagnosis, bladder pressures, a combination of clinical diagnosis and bladder pressure, or "other." The vast majority, 70% (n = 1,092) of respondents, believed that the diagnosis was determined by a combination of clinical diagnosis and bladder pressure. The clinical picture alone was all that was needed for 20% (n = 313) of respondents, 7.2% (n = 112) used bladder pressure alone to establish the diagnosis, and 1.2% (n = 20) and 1.6% (n = 25) of respondents listed a single or multiple "other" answers, respectively (Table 1).

Bladder Pressure Measurements. Questions 5 and 6 asked respondents if they were familiar with the procedure of bladder measurement and, if so, at what pressure they believed that physiologic compromise occurred. Of the respondents, 13.2% (n = 210) were unaware of a bladder pressure measurement procedure and 3.4% (n = 54) never used bladder pressure measurement because they did not believe it had clinical correlation. Nearly half of the respondents, 46.5% (n = 739) seldom used bladder pressure. Only a third, 35.9% (n = 571), used bladder pressures either often or routinely (Table 1).

Of the respondents who employed bladder pressure measurement, 42.5% (n = 543), believed that a value of 20–27 mm Hg (26–35 cm H_2O) was the pressure range at which there was physiologic compromise followed by 22.6% (n = 289) of respondents choosing a range of 12–19 mm Hg (16–25 cm H_2O). A significant number of respondents, 9.6% (n = 123), believed that physiologic comprise occurred at a pressure of >28 mm Hg (35 cm H_2O). Finally, 17.7% (n = 226) did not select a numerical value but believed that physiologic compromise was patient dependent (Table 1).

Clinical Causes of IAH/ACS. Question 7 assessed the frequency with which a clinical scenario was seen as causing IAH/ACS in the respondents' practice. The question listed five potential clinical causes with an additional space provided to list any "other" causes of IAH/ACS. Respondents were asked to give a numerical score of the frequency for each cause, ranging from 1 (never) to 5 (frequently). Table 2 provides the average numerical score given by respondents, with calculations for the entire group and individual specialties for comparison.

When all respondents were considered, the choice of "intra-abdominal trauma/bleeding with large volume resuscitation" had the highest average frequency score of 3.1, and "third spacing fluids" (from large volume fluid resuscitation in the setting of SIRS or sepsis) had the second highest average frequency score of 3.0 (statistical analysis was not performed between answer choices) (Table 2). Within training groups, surgeons and anesthesiologists chose "intra-abdominal trauma/bleeding with large volume resuscitation" as the most common cause of IAH/ACS more frequently than did other training specialties. Pediatric and medical intensivists rated "third spacing fluids" as the leading cause of IAH/ACS among the choices listed (Table 2).

There were a large number of "other" clinical causes listed by respondents, illustrating the broad spectrum of pathophysiology that can lead to IAH/ACS (Table 3). Of the additional clinical problems listed by respondents, pancreatitis and complication from abdominal aortic aneurysms were the most frequently mentioned.

Treatment Interventions. Question 8 assessed the utilization of common interventions in the treatment of IAH/ACS. The question listed five choices with additional space provided to list any "other" clinical interventions. Respondents were asked to designate a numerical score of frequency for each, from a range of 1, being never, to 5, being frequently. Table 4 details the average score chosen for each listed treatment from the entire group as well as individual specialties.

Overall, the respondents chose decom-

Table 2. Average numerical score (1 = never, 5 = frequently) of clinical cause of intra-abdominal hypertension or abdominal compartment syndrome by training (question 7)

	Entire Group	Surgery	Pediatrics	Anesthesia	Medicine
Intra-abdominal trauma/bleeding with large-volume resuscitation[a]	3.1	3.8	2.2	3.6	2.7
Intra-abdominal bleeding secondary to coagulopathy[a]	2.4	2.7	1.7	2.2	2.7
Ascites secondary to liver failure[a]	1.9	1.5	2.1	1.9	2.3
Third spacing (post-op, sepsis, systemic inflammatory response syndrome) with large volume resuscitation	3.0	3.1	2.9	3.0	2.8
Burn[a]	1.5	1.7	1.5	1.5	1.3
Other	1.8	1.9	2.1	1.9	1.6

[a]Group specialty differences are statistically significant, Kruskal-Wallis tied p value <.0001.

Table 3. "Other" listing of clinical causes of intra-abdominal hypertension and abdominal compartment syndrome and their listed frequency (question 7)

Other Choice Listed	No. of Responses
Pancreatitis	21
Abdominal aortic aneurysm complications	13
Congenital omphalocele/gastroschisis	6
Abdominal tumors	6
Bleeding with post-fluid resuscitation	5
Bowel infarction or ischemia	5
Intra-abdominal infection	5
Necrotizing enterocolitis	5
Postoperative cardiac surgery in infants	5
Retroperitoneal bleeding	5
Multiple trauma	4
Abdominal surgery complications	4
Post-fluid resuscitation	4
Bowel obstruction	3
Heart failure with increased venous pressure	3
Hernia repair	3
Multiple-system organ failure	3
Abdominal surgery	3
Ascites	2
Abdominal trauma	2
Hepatomegaly	2
Megacolon	2
Pneumoperitoneum	2
Reperfusion injury	2
Bone marrow transplant	1
Chest trauma	1
Extracorporeal membrane oxygenation	1
Head trauma	1
High inferior vena-caval obstruction	1
Intrinsic bowel disease	1
Large solid organ transplant	1
Lymphangiectasia	1
Paralytic ileus and Ogilvie's syndrome	1
Pelvic fracture	1
Peritonitis	1
Phototherapy-oncology	1
Post liver resection	1
Sarcoma	1
Scleroderma	1
Transverse rectus abdominis muscle flap	1
Volvulus	1
Total	134

pressive laparotomy along with fluid and blood products as the most frequently used intervention (Table 4). Analysis by training background demonstrated similar results with the exception of pediatric intensivists, who graded decompression laparotomy last among the intervention choices (Table 4). In contrast, pediatric intensivists selected pressors/inotropes and diuresis as their top choices. Also of note, medical intensivists gave paracentesis an average frequency score of 2.8, making it their second highest clinical management choice, but this treatment appears to be rarely used by surgical intensivists, who gave it their lowest score of 1.7. There was statistical significance between specialties ($p < .0001$) for both decompressive laparotomy and paracentesis when all four training specialties were compared (surgery, anesthesia, pediatrics, and medicine) (Table 4).

In addition to the intervention choices listed in question 8, the "other" treatment options given by the respondents are listed in Table 5. Frequently listed were dialysis, neuromuscular blocking agents, and peritoneal dialysis.

Consulting or Performing a Decompression Laparotomy. Question 9 asked respondents to rate factors that would lead them "to consult or perform a decompression laparotomy" on a patient with known or suspected elevated IAP. The list included worsening oliguria, increasing ventilator pressures, worsening acidosis, decreasing cardiac output, increasing oxygen requirements, and increasing pressor and/or inotrope requirements. Each factor was to be given a numerical grade from a scale of 1 to 5, with 1 defined as "would not affect my decision" and 5 defined as "would significantly affect my decision."

Overall, the choices of worsening oliguria and increasing ventilator pressure were selected as having the most significant effect on the decision to proceed with decompression laparotomy, with average scores for the entire group of 4.3 and 4.1, respectively. Analysis by training demonstrated similar results with the exception that decreasing cardiac output scored above increasing ventilator pressure for pediatric intensivists (3.9 vs. 3.7 average score) and medical intensivists (3.9 vs. 3.8 average score) (Table 6). (Statistical analysis was not performed between individual choices.)

Question 10 was a three-part question, with respondents being asked whether they would "consult or perform a decompression laparotomy" for elevated IAP alone, with a single additional factor, and with two additional factors. The additional factors were those listed in question 9. Respondents were increasingly likely to consult or perform a decompressive laparotomy as additional clinical factors (worsening oliguria, increasing ven-

Table 4. Average numerical score (1 = never, 5 = frequently) of interventions to treat intra-abdominal hypertension or abdominal compartment syndrome by training (question 8)

	Entire Group	Surgery	Pediatrics	Anesthesia	Medicine
Pressors/inotropes[a]	2.7	2.4	3.3	3.1	2.7
Diuresis[a]	2.3	1.9	3.3	2.0	2.3
Fluid/blood products[a]	2.9	2.8	3.2	3.1	2.8
Paracentesis[a]	2.4	1.7	3.1	2.1	2.8
Decompression laparotomy[a]	3.6	4.3	2.4	3.9	3.2
Other	1.9	2.1	2.1	2.0	1.4

[a]Group specialty differences are statistically significant, Kruskal-Wallis tied p value <.0001.

Table 5. "Other" listing of treatment options for intra-abdominal hypertension or abdominal compartment syndrome and their listed frequency (question 8)

Other Choice Listed	No.
Dialysis	17
Neuromuscular blockade agents	13
Peritoneal dialysis	6
Drains	2
Fluid	2
Ventilator management	2
Antibiotics	1
Escharotomy	1
Fasciotomy	1
Lasix/dopamine	1
Positioning	1
Total	47

tilator pressures, worsening acidosis, decreasing cardiac output, increasing oxygen requirements, and increasing pressor and/or inotrope requirements) were included in the scenario (Fig. 2). Of the respondents, 19.9% (n = 282) would decompress with elevated IAP alone, 62.6% (n = 875) with a single additional factor, and 87.9% (n = 1,221) with two additional factors.

Analysis by Primary Training and ICU Type. The results of the survey were further analyzed by considering the training and the type of ICU where the respondents were primarily working. Table 7 details the most common response when categorized by training for questions 3 through 6. Surgically trained intensivists working in a SICU recognized the highest number of ACS cases, with 50% of those respondents (n = 388) seeing four to ten cases and 19% seeing more than ten cases during the past year, with a range of 0 to 75 cases and an average of 8.1 cases. Medically trained intensivists working in an MICU (n = 164) and pediatric trained intensivists working in a PICU (n = 51) saw the fewest cases, with 34% and 33%, respectively, seeing zero cases of ACS in the past year. The range for these pediatric intensivists was 0 to 10 cases and the range for medical intensivists was 0 to 20 cases for the past year.

Overall, respondents agreed that the use of both bladder pressures and clinical variables was necessary for the diagnosis of IAH (70%) vs. bladder pressure (7%) and clinical variables (20%) alone (question 4, Tables 1 and 7). However, a significant number of pediatric intensivists working in a PICU (28.6%) and medical intensivists working in an MICU (23.8%) were unaware of a procedure for bladder pressure measurement as compared with surgically trained intensivists working in a SICU (<1%). When analyzing these last results by training alone, we found a statistically significant difference between surgical (2%) compared with pediatric (24%) and medical intensivists (23%) ($p < .0001$).

Forty-two percent of all of those surveyed believed that a bladder pressure ranging from 20–27 mm Hg would cause physiologic compromise; however, 25–27% of intensivists with pediatric, medicine, and anesthesia training believed this compromise would occur at bladder pressures of 12–19 mm Hg compared with 18% of the surgically trained intensivist (question 6). There were no respondents who believed that physiologic compromise occurred at pressures <8 mm Hg. Thirty-eight percent of pediatric-trained intensivists believed that physiologic compromise was patient dependent compared with a range of 7–17% from all other specialties ($p < .0001$).

In the management of IAH/ACS, 33% of pediatric intensivists and 20% of medical intensivists stated that they would never use decompression laparotomy to treat ACS compared with 3.6% of intensivists with surgical training and 5% with anesthesia training ($p < .0001$, question 8).

Table 8 describes the designated frequency given (N = never, F = frequently) based on primary training, with which respondents used a specific list of clinical interventions in the management of ACS and or IAH. This table demonstrates broad diversity in clinical management.

Follow-Up Survey. Two years after the completion of our initial survey, we performed a second, smaller survey to determine whether the substantial recent increase in IAH/ACS literature had an impact on the clinical practice of intensivists. The survey was performed during the 2005 Society of Critical Care Medicine Congress in Phoenix, AZ, and included 102 practicing intensivists. In this survey, 76% of intensivists agreed that "peer reviewed literature had convinced them that there is a correlation between high volume resuscitation in sepsis, IAH, and multiple organ failure." When asked to select "what percentage of your patient population (<1%, 1–10%, 11–25%, 26–50%, >50%) do you believe suffer adverse effects that may be caused by elevated IAP?" 50% of respondents answered between 1% and 10%. This was followed by 32% who chose the 11–25% range, 10% who chose the 26–50% range, and 7% who chose <1%; no one chose the highest category of >50%. Last, when asked to provide a yes-or-no answer to the following statement, "If you were given research information that demonstrated that IAH caused adverse patient outcomes (organ failure, death, increased length of ICU stay) AND that this occurs in 10 to 30% of your ICU population, would you begin monitoring more patients for IAP?", 94% of respondents answered yes.

DISCUSSION

To date, this is the largest assessment of the U.S. critical care community regarding the diagnosis and management of IAH/ACS. Several smaller surveys addressing this topic have been published. Mayberry et al. (32) surveyed 292 members of the American Association for the Surgery of Trauma from 1997 to 1998 and concluded that "a majority of expert American trauma surgeons have experience with ACS and would leave the abdomen open if ACS occurred . . . . A majority would re-open a closed abdomen in cases of elevated IAP with signs of clinical deterioration . . . . A minority would leave the abdomen open when there was only a risk of developing ACS" (32). Ravishankar and Hunter (33) completed a survey of 137 intensivists in the United Kingdom and concluded that "despite wide-spread awareness of IAH/ACS, many intensive

Table 6. Average numerical score (1 = would not affect, 5 = would significantly affect) of factors that would affect treatment decision to consult or perform decompressive laparotomy (question 9)

	Entire Group	Surgery	Pediatrics	Anesthesia	Medicine
Worsening oliguria[a]	4.3	4.5	3.9	4.4	4.2
Increasing ventilator pressures[a]	4.1	4.5	3.7	4.1	3.8
Worsening acidosis[a]	4.0	4.2	3.8	4.1	3.9
Decreasing cardiac output	4.0	4.0	3.9	3.9	3.9
Increasing oxygen requirements	3.4	3.6	3.4	3.5	3.3
Increasing pressor and/or inotrope requirements	3.5	3.5	3.4	3.5	3.5

[a]Group specialty differences are statistically significant, Kruskal-Wallis tied p value <.0001.

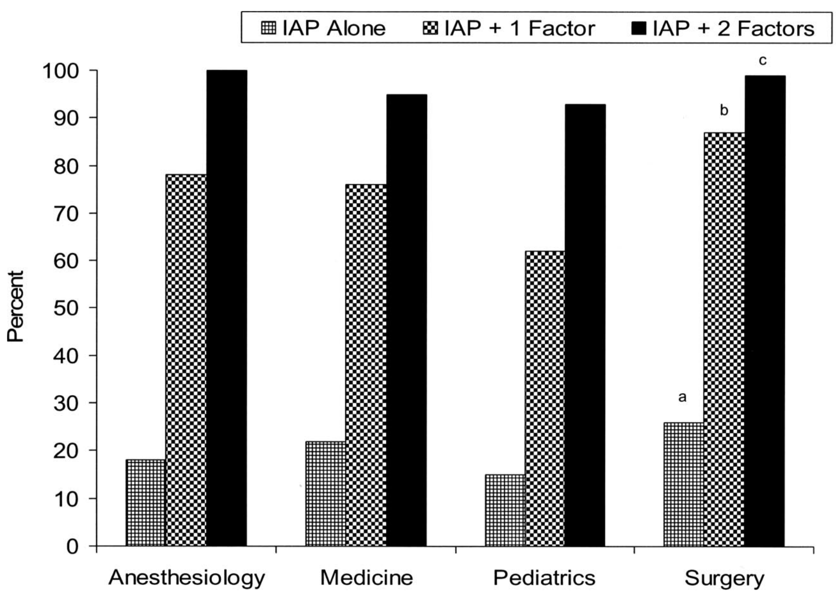

Figure 2. Response to question 10 (three parts—intra-abdominal pressure [*IAP*] alone, IAP with one additional factor, and IAP with two additional factors) based on intensivists' training. [a]Statistically significant difference between surgery and pediatric intensivists ($p = .0005$) for IAP alone. [b]Statistically significant difference between surgery and medical intensivists ($p < .0001$) and surgery and pediatric intensivists ($p < .0001$) for IAP with one additional factor. [c]Statistically significant difference between surgery and medical intensivists ($p = .002$) and surgery and pediatric intensivists ($p = .0001$) for IAP with two additional factors.

care units never measure the IAP- . . . . When it is measured, the intravesical route is used exclusively . . . . No consensus exists on optimal timing of measurement or when decompressive laparotomy should be performed" (33).

The demographics of our 1,622 survey respondents resulted in a general cross-sectional representation of SCCM physician members. The SCCM is unable to provide specific statistics regarding primary training or ICU work environment for physician members. SCCM representatives did state that medical and surgical intensivists represent the largest group of physician members, followed by pediatrics, anesthesia, and emergency medicine (personal communication, Ann K. Cox, Society of Critical Care Medicine, April 20, 2005). Based on percentages from our survey, there is likely an overrepresentation of surgical intensivists and underrepresentation of medical intensivists. We can only assume that experience with the survey topic may be reflected in the response rate. This may have resulted in a significant bias toward respondents who have more experience with IAH/ACS. In addition, the majority of respondents worked in an MSICU. Recent literature has demonstrated that IAH/ACS may be as common in MICU patients (28). An underrepresentation of MICU respondents would lead to selection bias against a patient population at significant risk for this pathophysiology. However, both of these selection biases would likely result in an overrepresentation of physicians with IAH/ACS management experience.

In assessing awareness of IAH/ACS, our survey reflected a broad range of experience with this pathophysiology as well as demonstrating a wide variation in the clinical management based on primary training. The survey results showed that IAH/ACS is most commonly diagnosed with a combination of clinical findings and the monitoring of bladder pressures. Most respondents believed that the most common cause of IAH/ACS was "intra-abdominal trauma/bleeding with large volume resuscitation" and "third spacing fluid." In managing IAH/ACS, most intensivists used decompressive laparotomy and fluid and/or blood products for treatment. Most intensivists graded worsening oliguria and increasing ventilator pressures as the clinical indicators considered for determining when to consult for or to perform a decompression laparotomy. Finally, most intensivists require at least one worsening clinical variable, in addition to elevated bladder pressures, before considering a decompression laparotomy.

A review of the current literature confirms that a significant percentage of critically ill patients are at risk for the development of ACS (28, 29). This syndrome, with a mortality rate approaching 70%, has been reported in a broad range of disease states that include medical and surgical adult and pediatric patients (28, 29, 34, 35). Unfortunately, if one waits until clinically apparent ACS develops, substantial tissue injury has already occurred. Ideally, management would be directed at detecting and intervening to treat elevated IAP before end organ damage occurs (36, 37). Simple monitoring of bladder pressures can give an accurate and consistent assessment of IAP (38–40).

Several recent articles have described IAP monitoring techniques (41, 42). Although not specifically addressed in this survey, most literature supports the transvesicular approach for IAP measurement. Done properly, this has been shown to correlate closely with overall IAP. A stopcock system can be constructed to accomplish this, or alternatively there are commercially available systems for IAP measurement: the Foley Manometer (www.holtech-medical.com), the AbViser (www.wolfetory.com), the IAP-Monitor (www.spiegelberg.de), and

Table 7. Breakdown of the most common response to questions 3 through 6 based on intensivists' training

Question	Survey Question Content	Anesthesia Trained	Medicine Trained	Pediatrics Trained	Surgery Trained
3	Approximate number of cases of abdominal compartment syndrome in last year (range)	1–3	1–3	1–3	4–7
4	How do you diagnose intra-abdominal hypertension?	Clinical diagnosis and bladder pressure	Clinical diagnosis and bladder pressure	Clinical diagnosis	Clinical diagnosis and bladder pressure
5	How often do you check bladder pressure?	Seldom	Seldom	Seldom	Often
6	At what pressure do you believe there is physiologic compromise (mm Hg)?	20–27	20–27	Patient dependent	20–27

Table 8. Percentage of respondents by training who designated the frequency of use of the listed interventions as never (N) or frequently (F) for question 8

	Anesthesia		Medicine		Pediatrics		Surgery	
	N	F	N	F	N	F	N	F
Pressors/inotropes	16	16	27	12	15	28[a]	37	8
Diuresis	50[a]	4	40[a]	9	19	26	49	4
Fluid/blood products	16	16	26	13	16	23	27	16
Paracentesis	44	4	23	13	14	16	59[a]	3
Decompression laparotomy	5	42[a]	20	26[a]	33[a]	9	4	63[a]

[a]Highest percentage in each column.

the CiMON (www.pulsion.com). Continuous IAP measurement techniques through a three-way Foley catheter system have also been recently described (43).

In a recent review by thought-leaders in ACS diagnosis and management, it was recommended that "the routine use of IAP monitoring is indicated for all patients at risk, which includes most of the massively injured or critically ill patients in the ICU" (44, 45). Drawing on available evidence, we have developed an IAP algorithm protocol to help guide monitoring and intervention decisions (Appendix 1). Physical exam has been shown to be grossly inaccurate and should not be used for the assessment of IAP (46, 47). Recent literature has also supported less invasive interventions in the management of IAH and ACS (48–56). Early monitoring and intervention may delay or prevent the need for decompression laparotomy (10, 36, 45). Cheatham et al. (56) demonstrated that the monitoring of abdominal perfusion pressure, calculated as the mean arterial pressure minus the IAP, was a better predictor of outcomes in the management of IAH/ACS.

Despite the large body of ACS literature, our survey demonstrated that there may be an underrecognition and significant variance in the approach to monitoring and management of IAH/ACS. Surgical intensivists appeared to have the most experience with ACS and therefore had a more consistent understanding of management using clinical diagnosis combined with bladder pressure and using abdominal decompression. The fact that definitive treatment for ACS is a surgical procedure may account for the increased recognition by surgically trained intensivists, but it may also lead to overdiagnosis. In addition, medical and pediatric intensivists may not consider this "surgical" diagnosis and treatment in nonsurgical patients despite studies demonstrating the significant incidence of IAH and ACS in the MICU. With a significant number of intensivists unaware of the standard method for IAP monitoring, it is likely that some patients with ACS are unrecognized and/or mistakenly viewed as "unresponsive to therapy."

CONCLUSION

Significant variation across medical training exists in the management of IAH/ACS. A significant percentage of intensivists may be unaware of current approaches to ACS management including monitoring bladder pressures and decompression laparotomy. Future research and education are necessary to establish clear diagnostic criteria and standards for treatment of this relatively common life-threatening disease process.

Clinical and bench research focused on IAH/ACS has grown rapidly in recent years. The vast majority of this research supports the clinical reality of IAH/ACS and the need for monitoring and treatment of at-risk critically ill patients. Although this pathophysiology may involve the expertise of many medical subspecialties, intensivists will clearly play a central role in establishing guidelines for the diagnosis and management of IAH/ACS. As with any pathophysiologic syndrome, definitions and standards must be established before definitive research and treatment protocols can be developed. A significant portion of IAH/ACS literature has suffered from an absence of these standards and definitions resulting in a paucity of evidence-based conclusions. Strides have recently been made with the formation of the World Society of Abdominal Compartment Syndrome. At the most recent congress held in Noosa, Australia, consensus definitions and standards for research and monitoring were established (www.wsacs.org). As this organization focuses its members and other interested clinicians on multiple-center IAH/ACS trials, practice guidelines will certainly be forthcoming.

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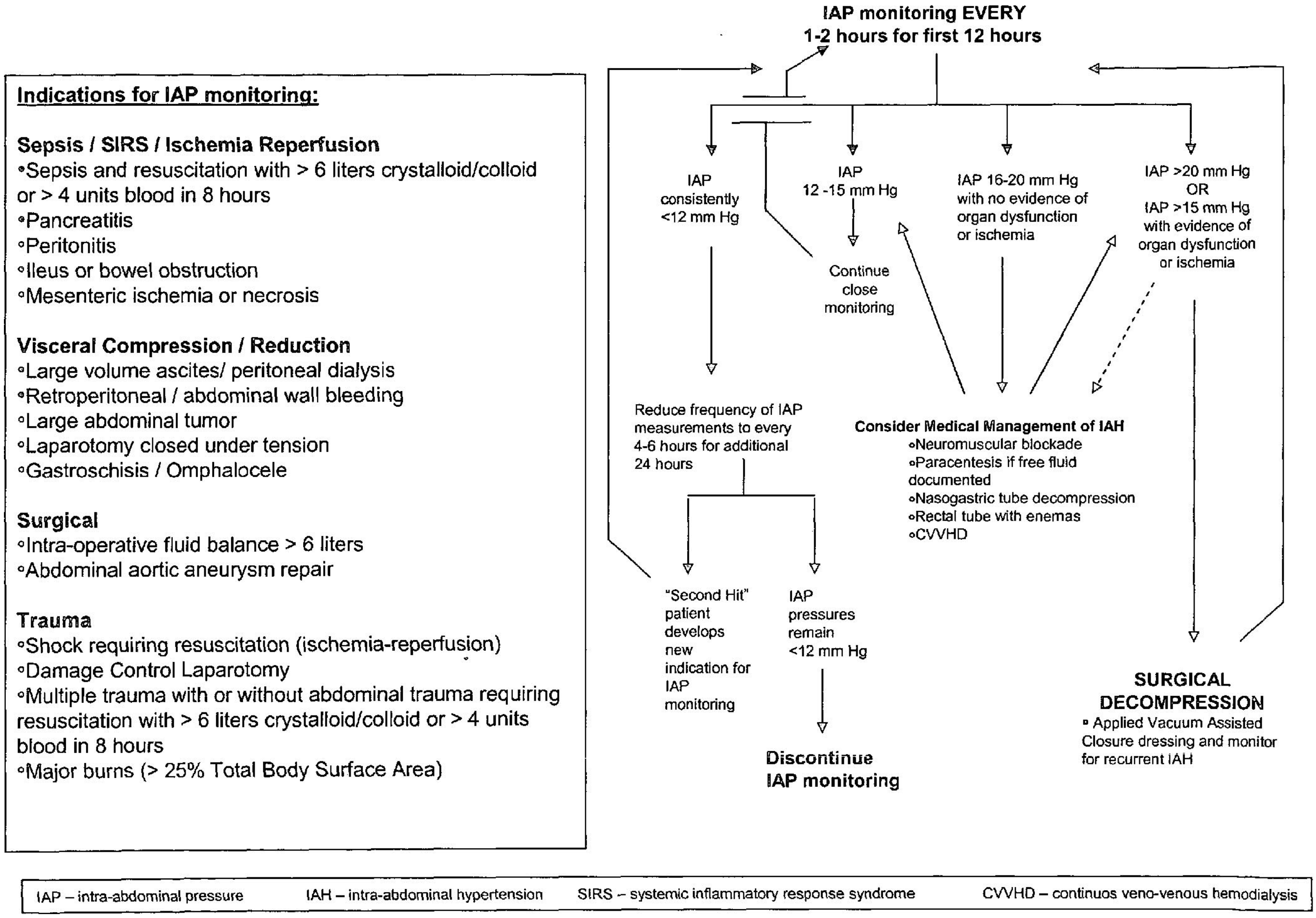

Appendix 1. Intra-Abdominal Pressure Monitoring Algorithm Used in the University of Utah Health Sciences Center Surgical Intensive Care Unit