VIA MEDICA

ORIGINAL AND CLINICAL ARTICLES

Anaesthesiology Intensive Therapy
2015, vol. 47, no 1, 14–29
ISSN 1642–5758
DOI: 10.5603/AIT.a2014.0051
www.ait.viamedica.pl

Awareness and knowledge of intra-abdominal hypertension and abdominal compartment syndrome: results of an international survey

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Abstract

Background: Surveys have demonstrated a lack of physician awareness of intra-abdominal hypertension and abdominal compartment syndrome (IAH/ACS) and wide variations in the management of these conditions, with many intensive care units (ICUs) reporting that they do not measure intra-abdominal pressure (IAP)**.** We sought to determine the association between publication of the 2006/2007 World Society of the Abdominal Compartment Syndrome (WSACS) Consensus Definitions and Guidelines and IAH/ACS clinical awareness and management.

Methods: The WSACS Executive Committee created an interactive online survey with 53 questions, accessible from November 2006 until December 2008. The survey was endorsed by the WSACS, the European Society of Intensive Care Medicine (ESICM) and the Society of Critical Care Medicine (SCCM). A link to the survey was emailed to all members of the supporting societies. Participants of the 3rd World Congress on Abdominal Compartment Syndrome meeting (March 2007, Antwerp, Belgium) were also asked to complete the questionnaire. No reminders were sent. Based on 13 knowledge questions, an overall score was calculated (expressed as percentage).

Results: A total of 2,244 of the approximately 10,000 clinicians who were sent the survey responded (response rate: 22.4%). Most of the 2,244 respondents (79.2%) completing the survey were physicians or physicians in training and the majority were residing in North America (53.0%). The majority of responders (85%) were familiar with IAP/IAH/ACS, but only 28% were aware of the WSACS consensus definitions for IAH/ACS. Three quarters of respondents considered the cut-off for IAH to be at least 15 mm Hg, and nearly two thirds believed the cut-off for ACS was higher than the currently suggested consensus definition (20 mm Hg). In 67.8% of respondents, organ dysfunction was only considered a problem with IAP of 20 mm Hg or higher. IAP was measured most frequently via the bladder (91.9%), but the majority reported that they instilled volumes well above the current guidelines. Surgical decompression was frequently used

to treat IAH/ACS, whereas medical management was only attempted by about half of the respondents. Decisions to decompress the abdomen were predominantly based on the severity of IAP elevation and presence of organ dysfunction (74.4%). Overall knowledge scores were low (43 ± 15%); respondents who were aware of the WSACS had a better score compared to those who were not (49.6% vs 38.6%, $P < 0.001$).

Conclusions: This survey showed that although most responding clinicians claim to be familiar with IAH and ACS, knowledge of published consensus definitions, measurement techniques, and clinical management is inadequate.

Key words: intra-abdominal hypertension, abdominal compartment syndrome, survey, knowledge, definitions, awareness, international

Anaesthesiology Intensive Therapy 2015, vol. 47, no 1, 14–29

Abdominal compartment syndrome (ACS) is now a well established condition [1], with studies addressing intra-abdominal pressure (IAP), intra-abdominal hypertension (IAH), and/or ACS being published at a hectic rate in recent years. Although the reasons for the growth in literature relating to these inter-related disease entities are not completely understood, it appears to have occurred in parallel with rising clinical understanding and interest. Though creation of an international group of dedicated clinician-scientists, the formation of the World Society of the Abdominal Compartment Syndrome (WSACS), a group dedicated to improving understanding of IAH and ACS (and related conditions such as the open abdomen), has undoubtedly contributed to these growths.

Possibly as a result of the growth in academic interest and published literature, insights into the pathophysiology, diagnosis, and treatment of IAH and ACS have advanced significantly from the early 1990s when Eddy et al. [2] among others published an overview on the subject. The literature resulting from this growth was first systematically synthesised and evaluated when the WSACS consensus definitions and recommendations were reported in 2006 and 2007, respectively [3, 4], and again in the updated definitions and clinical practice guidelines published in 2013 [5]. It remains unclear, however, to what extent healthcare professionals in clinical practice are aware of the definitions and recommendations proposed by these documents. It is also unclear whether these definitions/recommendations are required, how and when to apply them, as well as how clinicians perceive IAH and ACS to be of importance in the daily management of their patients.

Although previous surveys have been conducted regarding the perceived importance of IAH and ACS among practicing physicians, these have been met with several important limitations [6–17]. Almost all questionnaires were sent to a group of physicians in a single country, and were targeted at specific medical specialists, such as surgeons or intensivists, or specific types of intensive care units (ICUs), including burn units and neurosurgical ICUs [15]. Furthermore, the number of participants and response rates in these studies varied considerably (from 8–100%), raising the question as to whether the responses reported might be limited by selection or respondent bias.

The purpose of this international cross-sectional survey was to determine the association between publication of the 2006/2007 WSACS IAH/ACS Consensus Definitions/Clinical Management Guidelines, IAP measurement practices, and IAH/ACS clinical awareness and management among a multidisciplinary group of stakeholder clinicians.

METHODS

The WSACS Executive Committee created an interactive online survey (www.wsacs.org/survey.htm) that was accessible from November 2006 until December 2008. The survey was created based on the available knowledge on IAH/ACS at that time and based on the questions from previously published surveys. We did not identify a sampling frame nor was the survey tested or validated upfront. The survey was endorsed by the WSACS, the European Society of Intensive Care Medicine (ESICM, www.esicm.org), the European Critical Care Research Network (ECCRN), and the Society of Critical Care Medicine (SCCM, www.sccm.org). Emails containing the link to the survey were sent to all members of the supporting societies, as well as to all members of the Belgian Intensive Care Society (SIZ, www.siz.be). Participants in the 3rd WCACS (World Congress on Abdominal Compartment Syndrome) meeting (March 2007, Antwerp, Belgium) were also encouraged to complete the questionnaire. No reminders were sent after the initial emails. The questions from the survey can be found in Appendix 1. The survey consisted of 53 questions. Of these, a total of 13 questions were classified as knowledge questions with one or more correct answers. Based on the results of these questions, an average score for the correct answers could be calculated (expressed as percentage). Subgroup analysis was performed based on country of origin, primary specialty, and whether or not the participant was aware of the WSACS or the previously published consensus definitions.

RESULTS

RESPONDENT DEMOGRAPHICS

The survey was sent to approximately 10,000 participants and was completed by 2,244 respondents (with an estimated response rate of 22.4%). The professions of those responding were as follows: physicians (63.9%), nurses (10.6%), physicians in training (7.3%), respiratory therapists (0.6), nurses in training (0.2%), and others (3.3%). The profession of the respondent was not reported in 14.2% of surveys. Primary training of responding physicians included intensive care medicine (37.1%), trauma or surgery (24.0%), anaesthesiology (20.7%), internal medicine (7.9%), paediatrics (6.2%), emergency medicine (1.9%), cardiology (0.9%), and other (1.3%). Respondents resided in North America (53.0%), Europe (31.6%), Asia (7.2%), South America (4.8%), Australia (2.0%), and Africa (1.4%). Approximately 3% were members of the WSACS. Most respondents worked in a mixed medical/surgical ICU (55.3%), while the remainder worked in a trauma (30.4%), surgical (29.7%), cardiac (15.3%), medical (14.8%), paediatric (10.2%), burn (8.5%), or other ICU (4.8%).

IAH AND ACS DEFINITIONS

Of those who answered the question, 1,909 (85.6%) respondents claimed to be familiar with IAP and IAH while 1,903 (98.8%) were familiar with ACS. Nearly 70% were familiar with the concept of abdominal perfusion pressure (mean arterial pressure minus the IAP), and 28.4% were aware of the consensus definitions on IAH/ACS published in 2006 by the WSACS. Nearly 38% of respondents considered IAP to be normal when measuring between 0–5 mm Hg, whereas 46% of respondents thought values of 6–10 mm Hg were normal. Almost 14% considered 11–15 mm Hg to be the normal range for IAP and another 2.3% considered a normal IAP to be above 16 mm Hg. The majority of the respondents considered the cut-off for IAH to be at least 15 mm Hg (74.9%), and most (60.2%) thought ACS would only manifest at IAP levels 25 mm Hg (Table 1). Organ dysfunction was considered by 62.2% of respondents to occur at levels of 20 mm Hg or higher (Table 2).

Table 1. Responses to the question 'What intra-abdominal pressure (IAP) defines intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS)?'. The absolute numbers given as answers are represented in the columns as well as the percentage they comprise (the correct answer is represented by *)

Intra-abdominal pressure threshold	IAH	ACS
5 mm Hg	8 (0.4%)	Not applicable
10 mm Hg	117 (6.1%)	14 (0.7%)
12 mm Hg	338 (17.5%)*	19 (1.0%)
15 mm Hg	493 (25.6%)	71 (3.7%)
20 mm Hg	560 (29.1%)	561 (29.5%)*
25 mm Hg	97 (5.0%)	236 (12.4%)
> 25 mm Hg	292 (15.2%)	910 (47.8%)
Other	21 (1.1%)	92 (4.8%)
Total	1,926 (100%)	1,903 (100%)

Table 2. Responses to the question 'At what level of intra-abdominal pressure (IAP) do you think organ dysfunction may occur in patients with intra-abdominal hypertension (IAH)?' (the correct answer is noted by *)

Intra-abdominal pressure threshold	Frequency of responses	Percentage
10 mm Hg	62*	2.8%
12 mm Hg	127	5.7%
15 mm Hg	381	17.0%
20 mm Hg	628	28.0%
25 mm Hg	301	13.4%
> 25 mm Hg	692	30.8%
Other	53	2.4%
Total	2,244	100%

IAP MEASUREMENT

Most respondents measured IAP via the bladder (91.9%). Other routes used were direct/peritoneal (1.2%), transgastric (0.3%), or a combination of routes (6.3%). Only 17.2% instilled 10–25 mL of saline as proposed in the WSACS guidelines, with half of respondents (50.9%) instilling 50 mL. More than one fifth reported injecting 100 mL, and 4% used volumes as large as 200 mL. Nearly 7% documented the IAP reading promptly after instillation of saline, 35.2% waited 10–30 seconds, 36.6% waited 31–60 seconds, and 19% waited 61–120 seconds. The frequency of IAP monitoring was also variable: 3.5% monitored it continuously, 19.1% 4-hourly, 13.1% 6-hourly, 13.2% 8-hourly, 5.6% 12-hourly, 2.2% daily, 41.8% when clinically indicated, and 1.8% reported other timing regimes. Indications for IAP monitoring frequently mentioned included abdominal surgery, massive fluid resuscitation, and acute pancreatitis (Table 3). Four per cent of respondents did not measure IAP, mainly because of a lack of knowledge about measurement techniques and how to interpret its value (Table 4).

DIAGNOSIS OF IAH AND ACS

The preferred method for diagnosing IAH/ACS was reported to be the clinical picture in combination with an IAP value (69.9%). Nearly one quarter of respondents (23.2%) based their diagnosis on IAP measurement exclusively, while the remaining proportion relied only on clinical examination (3.5%), abdominal CT scan (0.9%), abdominal ultrasound (0.6%), and abdominal circumference (0.4%).

Table 3. Responses estimating in which medical and surgical patient population intra-abdominal pressure is routinely measured*. The high number of IAP measurement in patients at risk for IAH is probably related to the WSACS consensus definitions advocating IAP measurement in cases where two or more risk factors are present

Medical patients	(total 1,790)	Surgical patients	(total 1,790)
Patients at risk for IAH?	1,507* (84.2%)	Abdominal surgery	1,528 (85.4%)
Massive fluid resuscitation	1,168 (65.3%)	Trauma surgery	1,399 (78.2%)
Acute pancreatitis	1,028 (57.4%)	Massive fluid resuscitation	1,307 (73.0%)
Sepsis	879 (49.1%)	Emergency surgery	876 (48.9%)
Organ failure	831 (46.4%)	Vascular surgery	653 (36.5%)
Mechanical ventilation	338 (18.9%)	Obstetrics / gynaecology	266 (14.9%)
Obesity	305 (17.0%)	Neurosurgery	141 (7.9%)

Table 4. Reasons cited by those respondents who never measure intra-abdominal pressure for not measuring it

Reasons	Frequency	Percentage
I do not know how to measure IAP	31	37.3%
I do not know how to interpret IAP	13	15.7%
No equipment/staff to do it	6	7.2%
I'm not interested in the topic	5	6.0%
I think it has no clinical relevance	4	4.8%
I don't treat patients with IAH	3	3.6%
Other	21	25.3%
Total	83	100.0%

NUMBER OF ACS CASES

Almost all respondents (99.7%) reported that they had treated at least one patient with ACS in the last year. This survey revealed the majority of physicians (62.1%) treated 1–5 cases of ACS per year. Mean number of ACS cases reported per year was 7.1 ± 10. Participants who were aware of the WSACS saw more ACS cases 9.3 ± 11.9 vs 5.6 ± 8.2 ($P < 0.001$). Participants aware of the consensus definitions also identified more ACS cases 9.8 ± 13 vs 5.9 ± 8.1 ($P < 0.001$). Figure 1 shows a histogram with distribution of ACS cases seen per year per participant.

KNOWLEDGE OF IAH, ACS AND WSACS CONSENSUS DEFINITIONS

Within the survey there were 13 knowledge questions. Table 5 lists average scores on each of these questions. The overall average score of correct answers was only 43 ± 15% (range 0–100%). There was only one trauma surgeon with the maximum score of 100%, while only 29.6% of respondents had a score above 50%, and only 3.1% had a score above 75%.

Of importance, awareness of the WSACS was low, with an overall figure of 40.6% (doctors 42.5%, nurses 34.4%, and

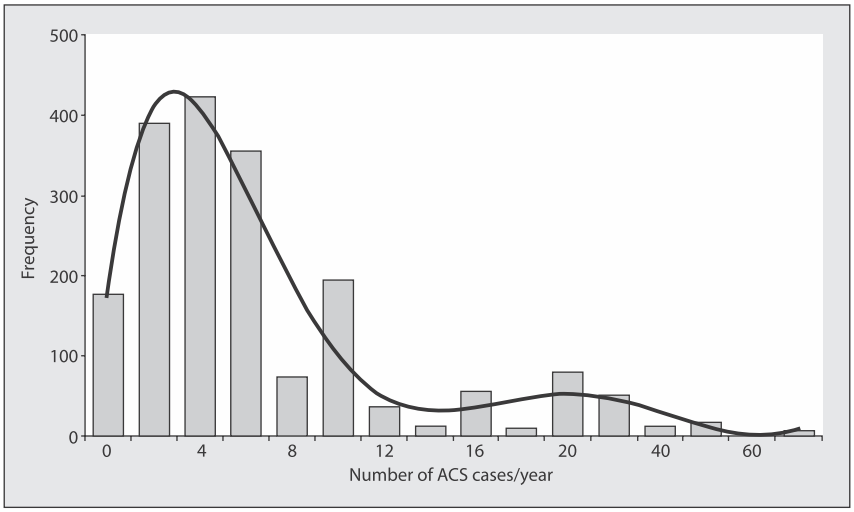

Figure 1. Average number of cases with abdominal compartment syndrome reported. Histogram with average number of cases of abdominal compartment syndrome seen annually was 7.1 ± 10 for each intensive care unit as estimated by the respondents in the survey

Table 5. The results of questions relating to diagnosis and monitoring of intra-abdominal pressure. The score represents the percentage of respondents replying correctly

Question	Correct answer	Score (%)
What is 'normal' IAP?	< 10 mm Hg	81
Are you familiar with the concept of abdominal perfusion pressure (APP = MAP–IAP)?	Yes	80.9
On what criteria do you base your decision to decompress a patient with ACS?	The combination of IAP and organ dysfunction	72.9
What is your PREFERRED method for diagnosing IAH/ACS?	Clinical examination + IAP measurement	69.9
Would you perform surgical decompression in a patient with ACS?	Yes, but only in selected cases	64.7
Are you aware of continuous IAP measurement techniques?	Yes	52.2
How often do you measure IAP?	Every 4 to 6 hours	29.6
What IAP level defines abdominal compartment syndrome (ACS)?	20 mm Hg	27.8
Are you familiar with the concept of the filtration gradient (FG) (FG = MAP–2*IAP)?	Yes	19.9
What IAP level defines intra-abdominal hypertension (IAH)?	12 mm Hg	17.5
For the transvesical (bladder) technique, how long do you wait before reading the IAP (i.e. to achieve a stable tracing)?	61–120 seconds	17.3
For the transvesical (bladder) technique, the volume instilled in the bladder before IAP measurement should be...	20–25 mL	15.7
At what level of IAP do you think organ dysfunction may occur in patients with intra-abdominal hypertension (IAH)?	10–12 mm Hg	9.7

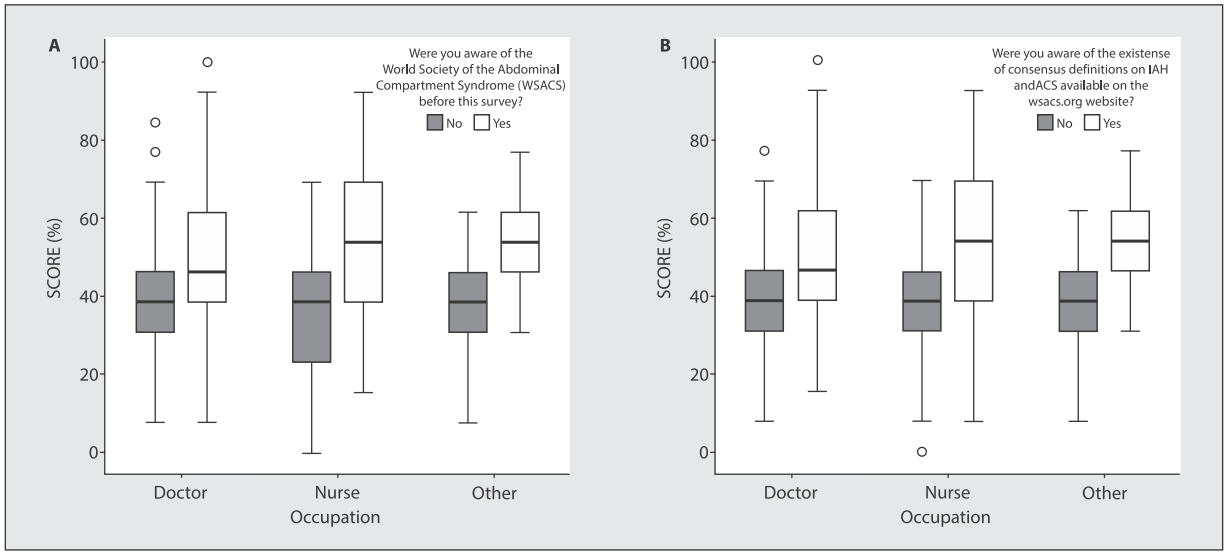

Figure 2. Average scores on knowledge questions. **A** — average score (in percentage) on the knowledge of IAH and ACS, according to occupation (doctor, nurse or other) of survey respondents and subgroup analysis in relation to awareness of the existence of the WSACS ($P < 0.001$ for all comparisons, one-way ANOVA); **B** — average score (in percentage) on the knowledge of IAH and ACS, according to occupation (doctor, nurse or other) of survey respondents and subgroup analysis in relation to awareness of the existence of the consensus definitions ($P < 0.001$ for all comparisons, one-way ANOVA)

other 23.9%). Awareness of the consensus definitions on IAH and ACS was even lower at 31.0% (doctors 32.2%, nurses 27.4%, and other 20.5%). Doctors had the highest score (43.4 ± 14.6) vs nurses (41.6 ± 17.4) and others (39.7 ± 13.2) with $P = 0.02$. Within each subgroup of doctors, nurses or others, the scores were significantly higher ($P < 0.001$ for all comparisons) if the participants were aware of the WSACS (Fig. 2A) or if they knew or heard about the consensus definitions (Fig. 2B).

Awareness of the WSACS's existence partly mirrored this response rate, with 59.2% of European respondents being aware of WSACS before the survey, but only 30.4% of North Americans being aware. Other areas had varied awareness for WSACS: Australia 54.8%, South America 50%, Africa 33.3%, and Asia 26.5%. The highest scores were obtained by participants coming from Europe (47.6 ± 15.9%), followed by Australia (44.9 ± 12.9%), Africa (44.5 ± 14.2%), South America (44.4 ± 15.6%), North America (40.3 ± 13.7%) and finally Asia

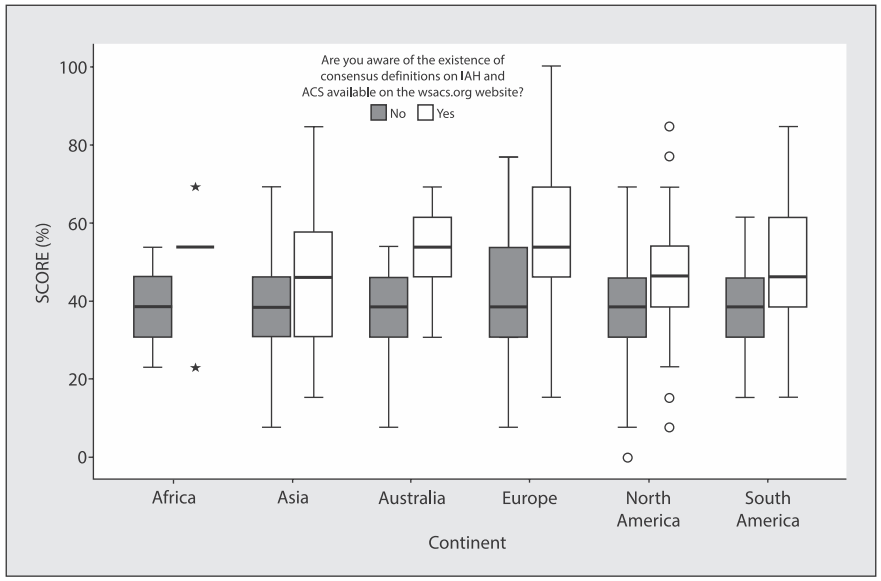

Figure 3. Average score (in percentage) on the knowledge of IAH and ACS, according to continent of residency of survey respondents and subgroup analysis in relation to awareness of the existence of the consensus definitions ($P < 0.005$ for all comparisons, except for Africa with P = NS, one-way ANOVA). See text for explanation

with an average score of 39.7 ± 14.1% ($P < 0.001$, one way ANOVA). Within each continent, the scores were significantly higher if the participants were aware of the WSACS or if they knew about the consensus definitions (Fig. 3).

The disciplines that showed greatest awareness of the WSACS were anaesthesiology (47.6%), trauma/surgery (47.0%), and intensive care medicine (42.4%) physicians. Awareness of the WSACS was particularly low among physicians from internal medicine (36.8%), emergency medicine (35.0%), cardiology (25.0%), paediatrics (22.9%), and others (13.6%). Knowledge of the existence of consensus definitions according to primary training was even lower, with surgery/trauma being the highest (38.0%), followed by emergency medicine (35.0%), intensive care medicine (32.7%), anaesthesiology (32.6%), internal medicine (28.9%), cardiology (25.0%), paediatrics (12.5%), and others (12.0%). The highest overall scores were obtained by participants with emergency medicine as their primary speciality (46.6 ± 17.7%), followed by anaesthetists (44.4 ± 14.4%), intensivists (44 ± 14.3%), trauma specialists or surgeons (43 ± 14.7%), with cardiologists having the lowest score of 30.8 ± 15.4% ($P = 0.01$, one way ANOVA). Within each primary specialty, the scores were significantly higher if the participants were aware of the WSACS or if they knew about the consensus definitions (Fig. 4).

RISK FACTORS FOR IAH/ACS

Respondents believed that large volume resuscitation (and 'third space fluid') had often caused IAH/ACS in their patient population during the previous year. This was followed by bowel perforation (faecal peritonitis), gastrointestinal tract surgery, ascites (secondary to liver failure), intra-abdominal bleeding (secondary to coagulopathy), vascular surgery, and burns. Figure 5 shows a bar graph presentation of the frequency of clinical conditions thought to be associated with IAH or ACS. Table 6 provides the average numerical score of the frequency of each clinical condition leading to ACS as experienced by the respondents compared to the scores obtained in the second largest survey by Kimball et al. [9].

TREATMENT INTERVENTIONS

Decompressive laparotomy was mentioned most often for the management of IAH/ACS (Fig. 6), followed by administration of vasopressors and inotropes, fluid and blood products, and diuretics, as well as use of abdominal paracentesis. Paediatricians were noted to be least likely to perform decompressive laparotomy in their patients to treat ACS versus surgeons/trauma surgeons who were most likely. Table 7 details the average scores of how frequently those interventions are applied depending on each specialty.

Nearly 65% intended to decompress the abdomen in selected cases only, whereas another 29.5% would perform a decompressive laparotomy regularly for treatment of ACS. Criteria for deciding to decompress the abdomen were predominantly the combination of IAP and organ dysfunction (74.4%), followed by the degree of organ dysfunction alone (8.9%), the cause of ACS (6.3%), the evolution of organ dysfunction (4.3%), and the evolution of IAP (2.1%).

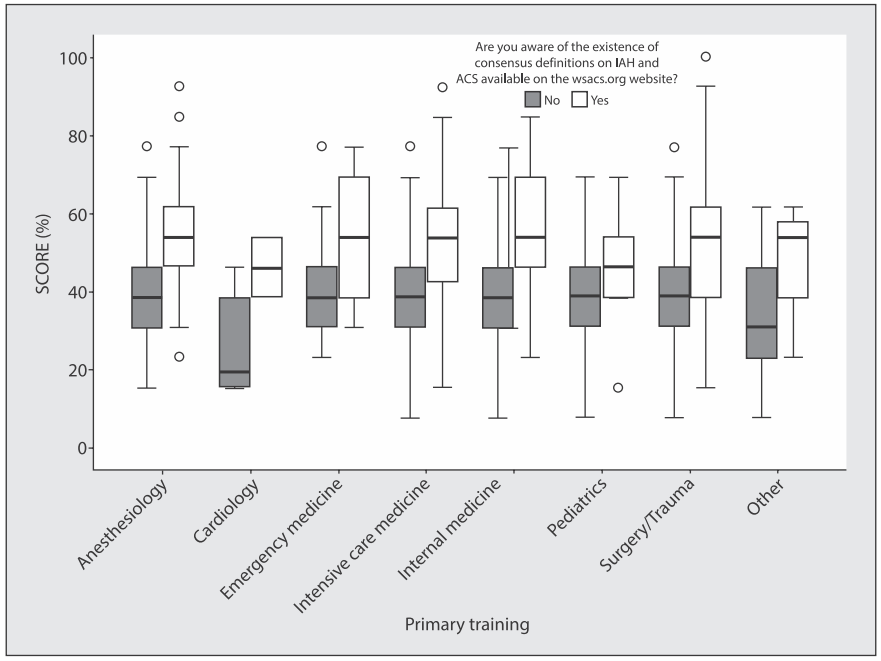

Figure 4. Average score (in percentage) on the knowledge of IAH and ACS, according to the primary speciality of survey respondents and subgroup analysis in relation to awareness of the existence of the consensus definitions ($P < 0.001$ for all comparisons, except for cardiology, emergency medicine, paediatrics and other with P = NS, one-way ANOVA). See text for explanation

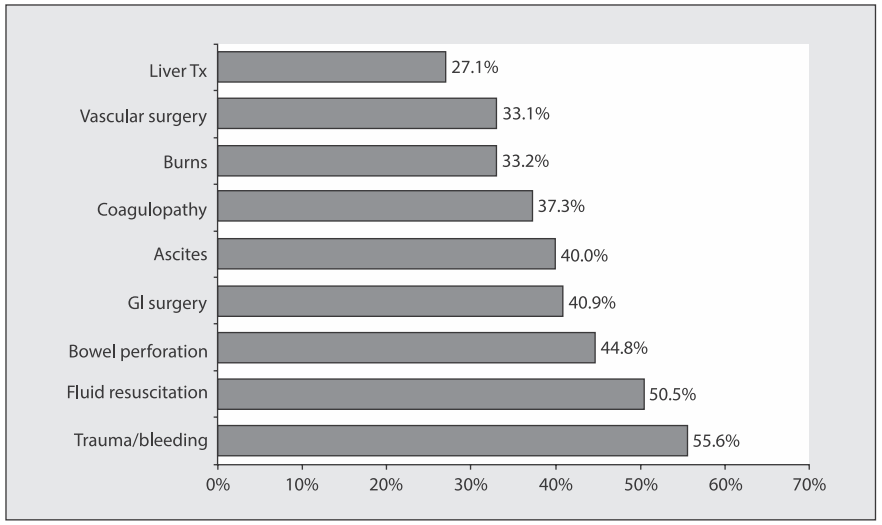

Figure 5. Bar graph presentation of the frequency (in percentage) of different clinical conditions thought to be associated with IAH or ACS

Table 6. The average numerical score (from 1 to 5: never/rarely/sometimes/frequently/usually) of clinical causes likely to result in intra-abdominal hypertension/abdominal compartment syndrome as perceived by respondents during the past year

	Mean score (1–5)	Kimball et al. study [15]
Intra-abdominal trauma / bleeding with large volume resuscitation	3.2	3.1
Third-space fluid with large volume resuscitation	3.1	3.0
Bowel perforation	2.9	
Gastrointestinal tract surgery	2.7	
Ascites secondary to liver failure	2.7	1.9
Intra-abdominal bleeding secondary to coagulopathy	2.5	2.4
Vascular surgery	2.4	
Burns	2.4	1.5
(Liver) Transplant surgery	2.1	
Other		1.8

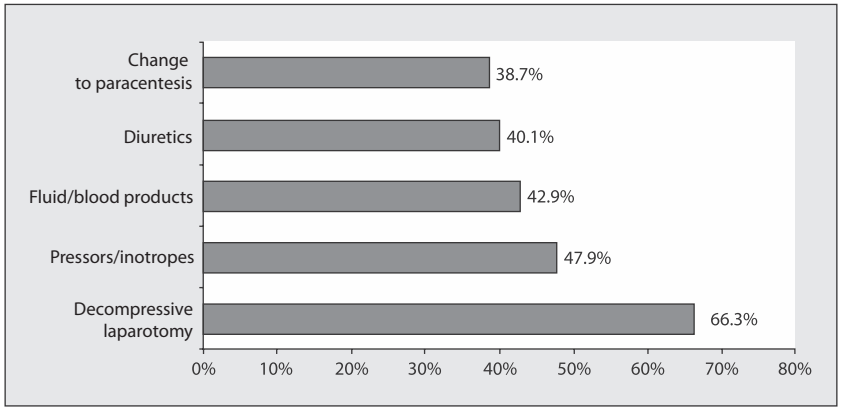

Figure 6. Bar graph presentation of the frequency (in percentage) of different treatment options for IAH or ACS

Table 7. The average numerical score (from 1 to 5: never/rarely/sometimes/frequently/usually) of interventions applied in treating intra-abdominal hypertension/abdominal compartment syndrome by training

	All respondents	Anaesthesia	Cardiology	Emergency	Intensive care	Internal medicine	Paediatric	Surgery/trauma	Other
Decompressive laparotomy	3.65	3.55	3.56	3.55	3.65	3.51	3.0	4.12	3.07
Vasopressors/inotropes	3.02	3.28	2.89	2.71	3.22	3.05	3.54	2.49	2.73
Fluid/blood products	2.77	2.74	2.11	2.86	2.86	2.62	2.78	2.68	2.53
Diuretics	2.68	2.84	2.89	2.43	2.64	2.36	3.25	2.41	2.8
Abdominal paracentesis	2.57	2.37	2.44	2.52	2.78	2.97	3.32	2.18	3.4

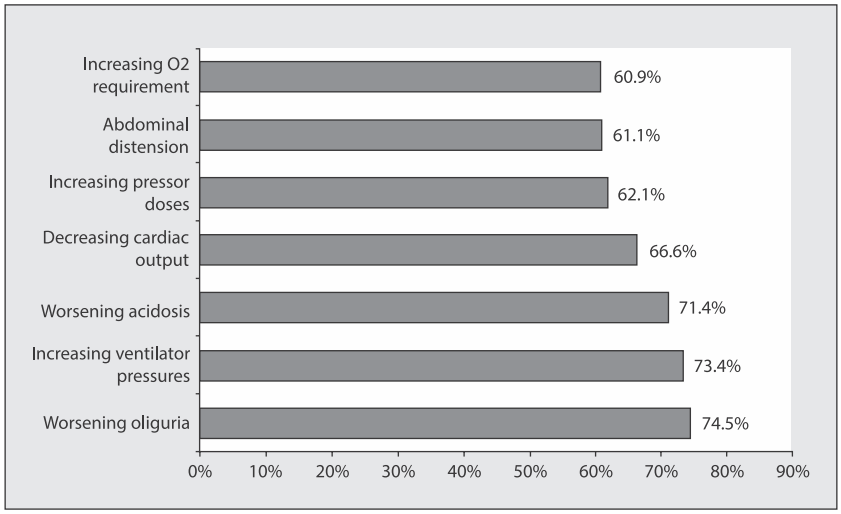

Figure 7. Bar graph presentation of the frequency (in percentage) of different indications for performing a decompressive laparotomy in ACS

Further criteria contributing to the decision to perform a decompressive laparotomy included worsening oliguria, worsening acidosis, increasing ventilator peak inspiratory pressures, decreasing cardiac output, and other (Fig. 7). Table 8 compares the average numerical scores from this survey with the second largest survey performed. Interestingly, fluids and blood products were used almost as frequently as diuretics in the management of IAH/ACS by all disciplines, with slightly more frequent use of diuretics amongst paediatricians.

Table 8. Average numerical score (1–5: never/rarely/sometimes/frequently-usually) of different factors affecting the decision to perform a decompressive laparotomy

	Mean score (1–5)	Kimball's study [9]
Worsening oliguria	3.9	4.3
Increasing ventilator pressures	3.9	4.1
Worsening acidosis	3.9	4.0
Decreasing cardiac output	3.7	4.0
Increasing pressor or inotrope doses	3.6	3.5
Increasing oxygen requirement	3.5	3.4
Abdominal distension	3.5	NA

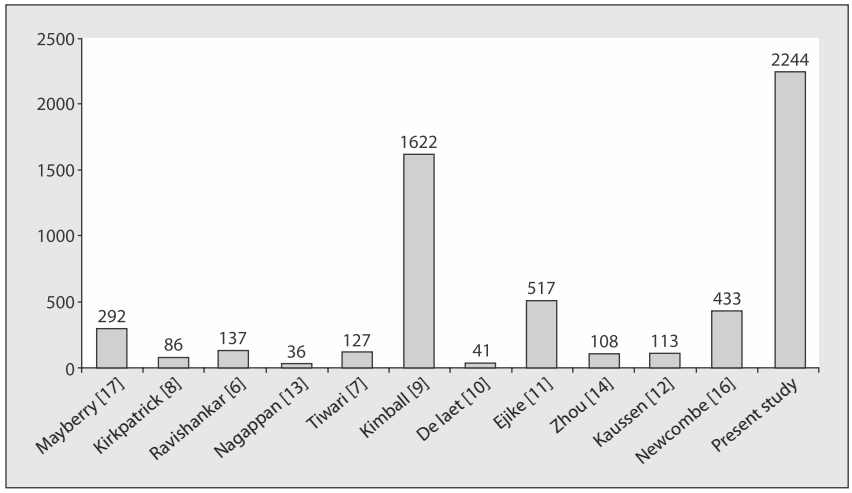

Figure 8. Bar graph representing numbers of respondents participating in surveys conducted on IAH/ACS. Total cumulative number of respondents is 5,756

After initial decompressive laparotomy, the open abdomen was treated with a vacuum assisted closure (VAC) in 39.2% of cases, a Bogota bag (silo) in 24.4%, a piece of synthetic or biologic mesh in 21.2%, and with immediate primary fascial closure in 2.9%, while other techniques accounted for 6.7%. After decompressive laparotomy, intensive care physicians, anaesthesiologists, and paediatricians most often use vasopressors and inotropes in management of ACS.

DISCUSSION

Several surveys have assessed the awareness and knowledge of IAP/IAH/ACS and its management. To date, this is the largest investigation (Fig. 8). More than 10,000 health care workers were contacted by e-mail. Unfortunately, it is not possible to provide exact information about the number of individuals approached since responders could be members of more than one of the supporting societies. Over 2,200 respondents participated in the current evaluation and the demographics from the data collected are representative of a number of continents. The low number of responses from Africa may be representative of limited access to internet based surveys at the time this survey took place. About 80% of respondents were doctors and more than 15% were critical care nurses. The primary discipline of respondents was predominantly intensive care medicine, followed by anaesthesiology and trauma/surgery. This is as expected, since the vast majority of respondents work in mixed surgical-medical, trauma, and surgical ICUs.

Of concern is the low number of respondents who could correctly classify the WSACS definition for IAH (17.5%) and ACS (29.5%). This correlates with the low level of awareness of the WSACS consensus definitions and guidelines (31.0%). This brings into question the reliability of the estimated number of cases of ACS identified annually. From this survey, results show that the majority of physicians (62.1%) identify ACS very rarely (1–5 cases per year). This figure is in stark contrast to previous research in this field. Malbrain et al. [18] showed an ACS prevalence of 8.2% in ICU patients in a multi-centre, multi-national study. A multicentre study looking at incidence, and a recent meta-analysis on the subject, showed that ACS occurs in around 4% of cases [19, 20]. A lower prevalence of 1.1% was found in the study by Reintam Blaser et al. [21], however, interpretation is limited

by the single centre design and not all consecutive admissions were included. The relatively low level of identification in this survey may indicate an improvement in ICU care, but is more likely to represent a continued lack of awareness of this problem.

Organ dysfunction was only considered to be a problem for 62.2% of the respondents at levels of 20 mm Hg or higher. This implies that 62.2% were unaware of the deleterious effects of increased IAP on end-organ function, which may begin to occur at the relatively low IAP of 10 mm Hg. Alternatively, it is reassuring that 84% of the respondents were aware of the normal range of IAP (0–10 mm Hg) [22].

Intra abdominal pressure measurement is performed in both surgical and medical patients. Indications for IAP monitoring include abdominal and trauma surgery, massive fluid resuscitation, acute pancreatitis, sepsis and organ failure. It was somewhat reassuring however that secondary causes of IAH/ACS were recognised, as these probably constitute the main burden of morbidity related to pathologically raised IAP [23–25]. However, from this survey it is evident that knowledge and understanding about this condition in the critical care healthcare providers is limited, and measurement of IAP is infrequently performed. The perception that IAH/ACS is commonly caused by intra-abdominal trauma/bleeding and large volume resuscitation is also supported by a previous survey by Kimball et al. [9].

In keeping with more recent findings from Zhou et al. [14], doctors appear to suspect ACS when there is intra-abdominal organ dysfunction, worsening oliguria, and increasingly difficult mechanical ventilation. Despite the vast majority correctly basing their IAH/ACS diagnosis on both clinical and IAP values, 23% of physicians still base their diagnosis of ACS on IAP alone. This demonstrates an inaccurate assumption and one that will lead to over-diagnosing of ACS.

It is inappropriate to make a diagnosis or therapeutic decision based on a single value, and more importantly, the trend and impact of end-organ function should be carefully considered when making such decisions. Of concern is the large percentage (41.8%) of respondents who relied on clinical suspicion as to when to monitor the intra-abdominal pressure. Clinical examination has been previously shown to be unreliable in predicting intra-abdominal pressure [26, 27].

When reviewing the technique of IAP measurements, more than nine out of ten survey participants performed the measurement via the bladder. The instillation volume used was excessive in more than 80%, probably overestimating the true IAP. Initially, 50 mL was recommended to estimate the IAP through bladder measurement [28]. This volume was reduced to 10–25 mL as higher volumes may overestimate the IAP [29–32]. Lack of knowledge regarding the measurement of IAP would obviously influence the frequency of diagnosis and correct classification of cases with IAH/ACS [33].

The 2006 WSACS consensus recommendations may not have been known to all respondents when this survey was undertaken, and may have contributed to these results. Similar results by Zhou et al. [14] have been identified, following the 2006 consensus recommendations, in which 84% of tertiary Chinese intensive care physicians also used instillation volumes not in keeping with current recommendations.

The most frequently chosen interventions in the management of IAH/ACS were performing a decompressive laparotomy, administering vasopressors and fluid management. Kimball et al. [9] showed analogous findings where vasopressors were ranked third. This may reflect uncertainty regarding the most optimal treatment of IAH and ACS. Based on current knowledge, non-surgical interventions are preferable and decompressive laparotomy should be avoided whenever possible. Interestingly, all specialties preferred decompressive laparotomy above alternative strategies, except for paediatric intensivists. In children, vasopressors and abdominal paracentesis appear to be used more often. This is remarkable, as a recently published paediatric survey declares that interventional-decompressive methods such as peritoneal drainage and paracentesis seem to play a minor part [12].

Despite the increase in publications on the topic, IAH/ACS is still an infrequently reported problem in children; nevertheless, Pearson et al. [34] recommended early decompressive laparotomy in the paediatric population. Factors influencing the decision for decompressive laparotomies are identical to those identified by Kimball et al. and illustrate the critical condition of the patient. This could explain why decompressive laparotomy is considered the preferred treatment. Decompressive laparotomy is often a subsequent alternative after prior options have failed in improving the patient's deteriorating condition, when organ dysfunction climaxes or in manifest emergency clinical conditions.

Surveys may be limited by non-representation of ICU protocols. A survey is susceptible to selection bias and might 'select out' those people who are particularly interested in the subject being studied. This may be the case with this study, despite the general lack of awareness and knowledge regarding definitions, guidelines, and management.

An advantage to this particular study is that invitations were sent to a wide variety of healthcare practitioners working in many varied places and ICUs. This may strengthen the validity of the responses received. However, the poor response from Africa, South America, and Asia will hopefully be addressed in future studies.

As with all surveys, some of the questionnaires reflect incomplete data, although the vast majority were completed in what is the largest survey on this subject. It should also be noted that this survey was completed in 2008, and thus may not reflect current knowledge.

CONCLUSIONS

Although improving, at the time of this survey there was a general lack of clinical awareness towards intra-abdominal hypertension and abdominal compartment syndrome. There was also a lack of clinical application of available knowledge about these subjects, particularly regarding diagnosing IAH/ ACS and monitoring intra-abdominal pressures.

IAP measurement is a widely performed monitoring parameter that is gaining more frequent use in daily ICU practice; however, many ICUs never measure it. The most preferred route of IAP measurement remains the transvesical route. Unfortunately, correct implementation of this technique is difficult and the correct instillation volume remains an Achilles heel, despite the update of the WSACS recommendations in 2006. Regarding management strategies for ACS, decompressive laparotomy is the most frequently chosen treatment. Finally, future re-evaluation of clinicians' knowledge and practice is essential, along with multi-centre clinical trials supported by the WSACS and its members.

ACKNOWLEDGEMENTS

The authors are greatly indebted to the supporting societies, namely the WSACS, ESICM, ECCRN, SCCM and SIZ for contacting their members with the online questionnaire. The authors are also indebted to Dr Michael L. Cheatham, Chief Surgical Quality Officer at Orlando Regional Medical Centre, a part of OrlandoHealth, for making the survey available online.

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Received: 17.08.2014
Accepted: 26.09.2014

APPENDIX 1: WSACS QUESTIONNAIRE

SURVEY QUESTIONS

1. Are you familiar with intra-abdominal hypertension (IAH) or the effect of elevated intra-abdominal pressure (IAP) on organ function?
   ☐ No
   ☐ Yes

2. Are you familiar with abdominal compartment syndrome (ACS)?
   ☐ No
   ☐ Yes

3. How many cases of ACS have you seen in the last year?

4. What is your PREFERRED method for diagnosing IAH/ACS?
   ☐ Abdominal perimeter/circumference
   ☐ Clinical examination of the abdomen
   ☐ Abdominal CT scan
   ☐ Abdominal ultrasound
   ☐ Intra-abdominal pressure (IAP) measurement
   ☐ Clinical examination + IAP measurement
   ☐ Other — Please specify the „Other" method you prefer to use to diagnose IAH/ACS.

5. What other methods do you use to diagnose IAH/ACS? (Please select as many as apply)
   ☐ Abdominal perimeter/circumference
   ☐ Clinical examination of the abdomen
   ☐ Abdominal CT scan
   ☐ Abdominal ultrasound
   ☐ Intra-abdominal pressure (IAP) measurement
   ☐ Clinical examination + IAP measurement
   ☐ None

6. What method(s) do you use to measure IAP (Please select all that apply)?
   ☐ Transvesical (bladder) measurement
   ☐ Direct (peritoneal) measurement
   ☐ Transgastric measurement
   ☐ Other — Please specify the „Other" method you use to measure IAP?

7. You have indicated that you do not measure IAP. Please explain why?
   ☐ I do not know how to measure IAP
   ☐ I think it has no clinical relevance
   ☐ I do not know how to interpret IAP
   ☐ I don't treat any patients with IAH
   ☐ Other — Please specify the „Other" reason why you do not measure IAP?

8. For the transvesical (bladder) technique, the volume instilled in the bladder before IAP measurement should be...
   ☐ 0 mL
   ☐ 10–25 mL
   ☐ 50 mL
   ☐ 100 mL
   ☐ 200 mL
   ☐ Other — What „Other" volume do you instill into the bladder for IAP measurement?

9. For the transvesical (bladder) technique, how long do you wait before reading the IAP (i.e., to achieve a stable tracing)?
   ☐ I do not wait. I measure IAP immediately
   ☐ 10–30 seconds
   ☐ 31–60 seconds
   ☐ 61–120 seconds
   ☐ Other — How long do you wait to read the IAP?

10. Are you aware of continuous IAP measurement techniques?
    - ☐ No
    - ☐ Yes

11. With which continuous IAP technique(s) are you familiar (please select all that apply)?
    - ☐ Intravesicular („Bladder")
    - ☐ Stomach
    - ☐ Direct peritoneal
    - ☐ Solid state transducer
    - ☐ Other — Which „Other" continuous IAP technique are you familiar with?

12. In which MEDICAL patient population(s) do you measure IAP (please select all that apply)?
    - ☐ Sepsis
    - ☐ Massive fluid resuscitation
    - ☐ Mechanical ventilation
    - ☐ Organ failure
    - ☐ Obesity
    - ☐ Acute pancreatitis
    - ☐ Patient at risk for IAH
    - ☐ Other — In what „Other" MEDICAL patient group do you measure IAP?

13. In which SURGICAL patient population(s) do you measure IAP (please select all that apply)?
    - ☐ Trauma surgery
    - ☐ Abdominal surgery
    - ☐ Neurosurgery
    - ☐ Vascular surgery
    - ☐ Emergency surgery
    - ☐ Obstetrics/Gynecology
    - ☐ Massive fluid resuscitation
    - ☐ Other — In what „Other" SURGICAL patient group do you measure IAP?

14. How often do you measure IAP?
    - ☐ Once every 24 hours
    - ☐ Once every 12 hours
    - ☐ Once every 8 hours
    - ☐ Once every 6 hours
    - ☐ Once every 4 hours
    - ☐ When clinically indicated
    - ☐ Continuously
    - ☐ Other — Please specify the frequency with which you measure IAP?

15. Are you familiar with the concept of abdominal perfusion pressure (APP = MAP – IAP)?
    - ☐ No
    - ☐ Yes

16. Are you familiar with the concept of the filtration gradient (FG) (FG = MAP – 2*IAP)?
    - ☐ No
    - ☐ Yes

17. What is „normal" IAP?
    - ☐ 0–5 mm Hg
    - ☐ 6–10 mm Hg
    - ☐ 11–15 mm Hg
    - ☐ > 16 mm Hg
    - ☐ Other — What value do you consider normal IAP?

18. What IAP level defines intra-abdominal hypertension (IAH)?
    - ☐ 5 mm Hg
    - ☐ 10 mm Hg
    - ☐ 12 mm Hg
    - ☐ 15 mm Hg
    - ☐ 20 mm Hg
    - ☐ 25 mm Hg
    - ☐ > 25 mm Hg
    - ☐ Other — What IAP value do you believe defines IAH?

19. What IAP level defines abdominal compartment syndrome (ACS)?
    - ☐ 5 mm Hg
    - ☐ 10 mm Hg
    - ☐ 12 mm Hg
    - ☐ 15 mm Hg
    - ☐ 20 mm Hg
    - ☐ 25 mm Hg
    - ☐ > 25 mm Hg
    - ☐ Other — What IAP value do you believe defines ACS?
    - ☐ For the following disease processes, please indicate how often the following clinical problems have caused IAH / ACS in your patient population during the past year.

20. Intra-abdominal trauma/bleeding with large volume resuscitation
    - ☐ Never
    - ☐ Rarely
    - ☐ Sometimes
    - ☐ Usually
    - ☐ Frequently
    - ☐ Not applicable

21. Intra-abdominal bleeding secondary to coagulopathy
    - ☐ Never
    - ☐ Rarely
    - ☐ Sometimes
    - ☐ Usually

☐ Frequently
☐ Not applicable

22. Vascular surgery
☐ Never
☐ Rarely
☐ Sometimes
☐ Usually
☐ Frequently
☐ Not applicable
☐

23. Gastrointestinal tract surgery
☐ Never
☐ Rarely
☐ Sometimes
☐ Usually
☐ Frequently
☐ Not applicable

24. Bowel perforation
☐ Never
☐ Rarely
☐ Sometimes
☐ Usually
☐ Frequently
☐ Not applicable

25. Ascites secondary to liver failure
☐ Never
☐ Rarely
☐ Sometimes
☐ Usually
☐ Frequently
☐ Not applicable

26. Third-space fluid with large volume resuscitation
☐ Never
☐ Rarely
☐ Sometimes
☐ Usually
☐ Frequently
☐ Not applicable

27. Burns
☐ Never
☐ Rarely
☐ Sometimes
☐ Usually
☐ Frequently
☐ Not applicable

28. (Liver) Transplant surgery
☐ Never
☐ Rarely
☐ Sometimes
☐ Usually
☐ Frequently
☐ Not applicable

29. At what level of IAP do you think organ dysfunction may occur in patients with intra-abdominal hypertension (IAH)?
☐ 5 mm Hg
☐ 10 mm Hg
☐ 12 mm Hg
☐ 15 mm Hg
☐ 20 mm Hg
☐ 25 mm Hg
☐ > 25 mm Hg
☐ Other – What level of IAP do you believe is associated with organ dysfunction?
☐ Please indicate the frequency with which you use the following interventions in treating IAH/ACS

30. Pressors/Inotropes
☐ Never
☐ Rarely
☐ Sometimes
☐ Usually
☐ Frequently
☐ Not applicable

31. Diuretics
☐ Never
☐ Rarely
☐ Sometimes
☐ Usually
☐ Frequently
☐ Not applicable

32. Fluid/Blood products
☐ Never
☐ Rarely
☐ Sometimes
☐ Usually
☐ Frequently
☐ Not applicable

33. Abdominal paracentesis
☐ Never
☐ Rarely
☐ Sometimes
☐ Usually

- ☐ Frequently
- ☐ Not applicable

34. Decompressive laparotomy
    - ☐ Never
    - ☐ Rarely
    - ☐ Sometimes
    - ☐ Usually
    - ☐ Frequently
    - ☐ Not applicable

35. Would you perform surgical decompression in a patient with ACS?
    - ☐ Yes, always
    - ☐ Yes, but in selected patients
    - ☐ Never
    - ☐ Other — In what situation would you perform surgical decompression?

36. On what criteria do you base your decision to decompress a patient with ACS?
    - ☐ The IAP
    - ☐ The degree of organ dysfunction
    - ☐ The cause of ACS
    - ☐ The evolution of IAP
    - ☐ The evolution of organ dysfunction
    - ☐ The combination of IAP and organ dysfunction
    - ☐ Other — Please specify the „other" criteria upon which you base your decision to decompress a patient with ACS?
    - ☐ Please rate how the following factors would affect your decision to consult or perform decompressive laparotomy on a patient with a known or suspected elevation in IAP.

37. Worsening oliguria
    - ☐ Never
    - ☐ Rarely
    - ☐ Sometimes
    - ☐ Usually
    - ☐ Frequently
    - ☐ Not applicable

38. Worsening acidosis
    - ☐ Never
    - ☐ Rarely
    - ☐ Sometimes
    - ☐ Usually
    - ☐ Frequently
    - ☐ Not applicable

39. Increasing ventilator pressures
    - ☐ Never
    - ☐ Rarely
    - ☐ Sometimes
    - ☐ Usually
    - ☐ Frequently
    - ☐ Not applicable

40. Increasing oxygen requirement
    - ☐ Never
    - ☐ Rarely
    - ☐ Sometimes
    - ☐ Usually
    - ☐ Frequently
    - ☐ Not applicable

41. Decreasing cardiac output
    - ☐ Never
    - ☐ Rarely
    - ☐ Sometimes
    - ☐ Usually
    - ☐ Frequently
    - ☐ Not applicable

42. Increasing pressor or inotrope doses
    - ☐ Never
    - ☐ Rarely
    - ☐ Sometimes
    - ☐ Usually
    - ☐ Frequently
    - ☐ Not applicable

43. Abdominal distension
    - ☐ Never
    - ☐ Rarely
    - ☐ Sometimes
    - ☐ Usually
    - ☐ Frequently
    - ☐ Not applicable

44. How do you most commonly deal with the open abdomen after the INITIAL decompression?
    - ☐ Immediate primary fascial closure
    - ☐ Temporary abdominal mesh
    - ☐ Bogota bag or silo
    - ☐ Homemade „vacuum-pack" closure
    - ☐ KCI VAC (vacuum-assisted closure) device
    - ☐ Skin-only closure
    - ☐ Other

45. How do you most commonly deal with the open abdomen after SUBSEQUENT abdominal explorations?
    - ☐ Immediate primary fascial closure
    - ☐ Temporary abdominal mesh
    - ☐ Bogota bag or silo
    - ☐ Homemade „vacuum-pack" closure
    - ☐ KCI VAC (vacuum-assisted closure) device
    - ☐ Skin-only closure
    - ☐ Other

46. What type of temporary mesh closure do you prefer?
    - ☐ Vicryl/Dexon mesh
    - ☐ Prolene/Marlex mesh
    - ☐ Vipro mesh
    - ☐ Gortex
    - ☐ Dermal template (Alloderm, Xenmatrix)
    - ☐ Other — Please specify what „Other" type of closure you perform?

47. Were you aware of the World Society of the Abdominal Compartment Syndrome (WSACS) before this survey?
    - ☐ No
    - ☐ Yes

48. Are you aware of the existence of consensus definitions on IAH and ACS available on the wsacs.org website?
    - ☐ No
    - ☐ Yes
    - ☐ We greatly appreciate your time in taking this survey. Please take just a few moments more to tell us about you and your institution.

49. What is your occupation?
    - ☐ Doctor
    - ☐ Doctor in training
    - ☐ Nurse
    - ☐ Nurse in training
    - ☐ Respiratory Therapist
    - ☐ Other — Please specify your occupation.

50. What is your area of primary training?
    - ☐ Anesthesiology
    - ☐ Cardiology
    - ☐ Emergency Medicine
    - ☐ Internal Medicine
    - ☐ Intensive Care Medicine
    - ☐ Pediatrics
    - ☐ Surgery/Trauma
    - ☐ Other — Please specify the area of your primary training.

51. What type of intensive care unit (ICU) do you work in primarily (choose as many as apply)?
    - ☐ Medical
    - ☐ Medical — Surgical
    - ☐ Surgical
    - ☐ Trauma
    - ☐ Burn
    - ☐ Pediatric
    - ☐ Cardiac
    - ☐ Other — Please specify the type of „Other" type of ICU you work in?

52. Which of the following societies are you a member?
    - ☐ World Society of the Abdominal Compartment Syndrome (WSACS)
    - ☐ European Society of Intensive Care Medicine (ESICM)
    - ☐ Society of Critical Care Medicine (SCCM)
    - ☐ International Trauma Anesthesia and Critical Care Society (ITACCS)
    - ☐ American Association for the Surgery of Trauma (AAST)
    - ☐ Eastern Association for the Surgery of Trauma (EAST)
    - ☐ Western Trauma Society
    - ☐ American Trauma Society (ATS)
    - ☐ American College of Surgeons
    - ☐ Trauma Association of Canada
    - ☐ Royal College of Surgeons of England
    - ☐ Royal Australasian College of Surgeons (RACS)
    - ☐ Royal College of Physicians and Surgeons of Canada
    - ☐ European Society of Anesthesiology (ESA)
    - ☐ Société de Réanimation de la Langue Française (SRLF)
    - ☐ Other — Please indicate which „Other" societies you are a member of
    - ☐ None

53. Please specify which continent you work in?
    - ☐ Europe
    - ☐ Asia
    - ☐ Australia
    - ☐ North America
    - ☐ South America
    - ☐ Africa