ABDOMINAL COMPARTMENT SYNDROME

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ABDOMINAL COMPARTMENT SYNDROME

INTRODUCTION

Research is being conducted further on intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS), and 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, first published in 2006.1,2,3, 4 The existing consensus definitions and guidelines were finalised in 2013. 4

Most physicians are not aware of IAH/ACS 5, and studies are showing evidence that the incidence of IAH in patients that are critically ill is about 50 percent and with this; 32.1 percent develop IAH whilst 4.2 percent develop ACS in intensive care unit (ICU) on their first day. 6 It is important to know and realize that complications as a result of IAH and ACS could be life threatening to ill patients, who are also critical.6 Organ perfusion can be altered and its function end as a consequence of these conditions. 6

DEFINITIONS

Definitions from the 2006 consensus statements 4,7

1. Intra-abdominal pressure (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 ≥ 12 mmHg
6. ACS is defined as a sustained IAP > 20 mmHg (with or without an abdominal perfusion pressure [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. MAP being mean arterial pressure
New definitions from 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.

Paediatric specific definitions

16. 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.

17. 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.

18. IAP in critically ill children is approximately 4–10 mmHg.

19. IAH in children is defined by a sustained or repeated pathological elevation in IAP > 10 mmHg.

ETIOLOGY OF INTRA-ABDOMINAL HYPERTENSION

There are numerous risks or physiological factors that can change a person’s intra-abdominal pressure and these can be categorized as follows:

Diminished abdominal wall compliance

- Surgery of the abdomen, and tight abdominal closures
- Bleeding of the abdominal wall, or rectus sheet hematoma
- Major burns with abdominal eschars
- Prone positioning
- Pregnancy
- Obesity or raised body mass index (BMI)
- Repair of massive incisional hernia
- Mechanical ventilation and accessory muscle use during ventilation
- Positive end expiratory pressure (PEEP) > 10 or the presence of auto PEEP
- Interstitial and abdominal wall oedema
- Pneumatic anti-shock garments
- Basal pleuropneumonia
- Pneumoperitoneum
Increased intra-luminal contents 4, 6, 10, 12 & 14

- Gastroparesis
- Gastric distention
- Ileus
- Colonic pseudo-obstruction
- Volvulus
- Colonic abdominal tumour
- Enteral feeding

Increased intra-abdominal contents 4, 6, 10, 12 & 14

- Acute pancreatitis
- The abdomen that is distended
- Hemoperitoneum
- Pneumoperitoneum
- Intra-peritoneal fluid collections
- Intra-abdominal infection
- Abscess in the abdomen
- Tumours that are intra-abdominal or retroperitoneal
- Laparoscopy done with excessive insufflation pressures
- Liver dysfunction
- Cirrhosis with ascites
- Peritoneal dialysis
- Major trauma (liver or spleen rupture)
- Damage control laparotomy
- Ruptured aortic aneurysm
- Post-operative abdominal surgery

Capillary leak/fluid resuscitation 4, 6, 10, 12 & 14

- Acidosis (pH less than 7.2)
- Hypothermia (the core temperature less than 33°)
- Coagulopathy (platelets less than 50 000/mm3, APTT more than twice normal, INR value greater than 1.5)
- Massive fluid resuscitation or positive fluid balance (using more than 3 litres of colloids or more than 10 litres of crystalloid in 24 hours when there is capillary leak and fluid balance being positive)
- Polytransfusion (>10 units in 24 hours)
- Increased APACHE-II or SOFA score
- Bacteremia
- Sepsis
- When in septic shock
- Major Burns.

IAH has also been reported in the group of medical and surgical pediatric patients with the associated disease states listed on table 1 below. 8
Table 1. Conditions that are associated with increased risk for ACS in children

<table>
<thead>
<tr>
<th>Primary ACS</th>
<th>Secondary ACS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastroscelisis</td>
<td>Aggressive fluid resuscitation</td>
</tr>
<tr>
<td>Omphalocele</td>
<td>Sepsis/Capillary leak syndrome</td>
</tr>
<tr>
<td>Necrotizing enterocolitis (NEC)</td>
<td>Multiple transfusions of blood products</td>
</tr>
<tr>
<td>Abdominal tumors</td>
<td>Multiple trauma</td>
</tr>
<tr>
<td>Intra-abdominal infections e.g. appendicitis,</td>
<td>Failed Fontan procedure/Heart failure with increased venous pressure</td>
</tr>
<tr>
<td>peritonitis, toxic megacolon</td>
<td>Hyperthermia</td>
</tr>
<tr>
<td>Bowel obstruction, ischemia or infarction</td>
<td>Renal failure</td>
</tr>
<tr>
<td>Abdominal trauma/hemorrhage</td>
<td>Extracorporeal membrane oxygenation</td>
</tr>
<tr>
<td>Complications of abdominal surgery</td>
<td>Burns</td>
</tr>
<tr>
<td>Ascites</td>
<td>Bone marrow transplant</td>
</tr>
<tr>
<td>Disproportionate solid organ transplant</td>
<td></td>
</tr>
<tr>
<td>Ileus, aganglionosis, constipation</td>
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</tr>
</tbody>
</table>

HOW DO WE DETECT RAISED IAP, IAH AND ACS?

Clinical examination alone is not accurate in detecting increased IAP, IAH and ACS. Studies have proved that management is based upon accurate serial or continuous IAP measurements. Monitoring and measuring IAP will ensure that we detect IAH early, then initiate medical treatment and prevent development of ACS. Patients with open abdomens also need monitoring of IAP, although the risk for ACS is not increased, new problems (for example; re-bleeding) can occur where rising IAP is the first sign or additional information needed in making diagnosis.

The presence of IAH and ACS in patients who have sustained injuries from trauma can be anticipated at evaluation in casualty or the trauma emergency departments (see table 2). Currently more and more patients who have sustained blunt abdominal trauma are treated conservatively, and there may be a growing risk for IAH and ACS.

Table 2. Predictors of ACS in trauma patients

<table>
<thead>
<tr>
<th>Primary ACS</th>
<th>Secondary ACS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature below 34° Celsius</td>
<td>Administration of more than 7.5 litres of crystalloids before admission to ICU</td>
</tr>
<tr>
<td>Haemoglobin less than 8 g dL(^{-1})</td>
<td>No indication for lifesaving surgical intervention</td>
</tr>
<tr>
<td>Base deficit below 8 mmol L(^{-1})</td>
<td>Relatively low urine output (&lt; 150 mL/hr) on ICU admission considering the massive resuscitation</td>
</tr>
<tr>
<td>Administration of &gt; 3 L of crystalloids</td>
<td>Poor intestinal perfusion measured by gastric tonometry</td>
</tr>
<tr>
<td>Transfusion of PRBC ≥ 3 Units</td>
<td></td>
</tr>
<tr>
<td>A need for emergency surgery</td>
<td></td>
</tr>
</tbody>
</table>
MEASUREMENT OF INTRA-ABDOMINAL PRESSURE

There are a number of techniques used to measure IAP and these can be via the gastric, intra rectal, inferior vena cava and a urinary catheter pressure monitoring systems. Trans-bladder measurement described by Kron is still a method that is used commonly, and was recommended in 2006 by the WSACS because it is simple and cost less. The Kron method (discussed at WSACS) measures the IAP via bladder and using sterile saline.

Before measuring of IAP takes place, the following must be done:

- Explain the procedure to an awake patient, and if asleep ensure good sedation
- First empty the bladder
- The patient must be positioned supine
- The transducer to be used must be zeroed, its position be in line with the iliac crest and mid-axillar
- A volume of saline that is not greater than 25 mL is to be instilled
- Wait 30 to 60 seconds, allowing bladder detrusor muscle to relax after instillation of saline
- The measurement has to be done at end-expiration

The transducer (figure 1) and measurement

Using figure 1 (when not measuring), all stopcocks are closed or turned off to the IV infusion bag, syringe and the transducer giving a way open for urine to flow into the drainage bag.
During measurement: 4, 9
1. The drainage tubing of urine is clamped distally to the ramp and stopcock number 3 is opened to the transducer side and the patient’s, and closed off to drainage. This 3rd stopcock is used also to be a clamp.
2. The first stopcock closed to the patient’s side and opened to the IV infusion bag, the second stopcock also opened to the IV infusion bag plus to the 60-mL syringe.
3. 20 to 25mls of sterile saline is aspirated into the syringe, from the IV bag.
4. Stopcock number 1 is then turned on to side of the patient and closed to that of the IV bag, and the aspirated saline in the syringe is instilled into the bladder via the urinary catheter.
5. Stopcock 1 & 2 must remain closed off to the IV tubing and syringe. Stopcock 3 already opened to the transducer side and the patient’s, shows the reading of intravesical pressure (IVP) on the monitor.

The Foley Manometer (figure 2) and measurement 9

![Diagram]

This forms a sterile circuit which is closed and connected between the Foley catheter and the bag collecting urine. IAP measurement takes about 10 seconds, and there is no requirement to correct urine output later. IAP in a range from 0 - 40 mmHg can be measured, and this technique being ideal in screening critically ill patients for suspected IAH. 9

Measurement of IVP: 9
1. The marking of 0 mmHg on the manometer tube; is placed at the line of the mid axillary and the level of the iliac crest, requiring one to mark as a reference for future measurements, whilst also elevating vertically the filter above the patient.
2. The bio-filter clamp is opened, and reading of IVP (end-expiration value) after about 10 seconds stabilization of the meniscus.
3. After the measurement, close clamp and the Foley Manometer must then be placed in the position for drainage.
Measurement using a manometer (administration set), are expressed in cmH2O (the height of the fluid column in the manometer in cm above the midaxillary line). Pressures measured in cmH2O using this system must preferably be converted to mmHg for purposes of standardized documentation and management. Conversion: IAP (mmHg) = IAP (cmH2O) ÷ 1.36

Continuous trans-bladder pressure monitoring systems have been suggested, as there would be no missed elevations in IAP but this technique may be expensive. However it was discussed at the last consensus that it is critical to note the initial baseline measurement before continuous IAP measurement can be started.

Measurements with a nasogastric tube an option to be used when:
- The patient is without a placed in Foley catheter,
- There is no free movement of the bladder wall; and accurate bladder pressures not possible to measure
- Bladder trauma present,
- The patient has adhesions of the peritoneum,
- Haematomas in the pelvis or the presence fractures,
- Packing of the abdomen has been done.

Disadvantage of this method:
There might be interference of the migrating motor complex by the gastric pressures and nasogastric feeding disturbed. All air present in the stomach has to be aspirated before the measurement of IAP, and that is something difficult to do plus verify.

When do we stop measurements?
When there is no acute organ dysfunction, and the values of IAP measured should be on a decreasing trend, being less than 10 mm Hg in the last 24 to 48 hours.

ADVERSE EFFECTS OF IAH AND ACS

Cardiovascular system
- The increase in IAP decreases cardiac output, as there is also reduced preload caused by pressure exerted on the inferior vena cava and intra-abdominal circulation.
- The venous return is reduced
- Development of peripheral oedema
- The central venous pressure increases
- With the myocardium that is working harder, the pulmonary artery wedge pressures increase.

Respiratory system
- The diaphragm moves up, with increasing IAP, reducing intra-thoracic space and respiration restricted. This resulting to increased pressure in the thorax, which is notable on patients that are mechanically ventilated.
- Lung compliance decrease as a result.
- There is reduction in functional residual capacity (FRC).
- A ventilation perfusion (VQ) mismatch occurs
- Hypoxia transpires.
Central nervous system
- As the jugular venous pressure gets elevated; Intra cerebral pressure increases and the cerebral blood flow decreases.

Renal system
- Oliguria, and with increasing IAP’s; anuria develop even with vigorous fluid administration during resuscitation.
- There is decreased renal blood flow in addition to a reduced cardiac output.
- Activation of the rennin angiotensin system.

Gastrointestinal system
- The vascular resistance is increased and cardiac output decreased, leading to a decrease in tissue perfusion.
- Tissue ischemia develops.
- Visceral hypoperfusion occurs, with secondary bacterial translocation.

Other effects
- Impaired abdominal wound healing,
- Increased cytokine response.

POLYCOMPARTMENT SYNDROME

A poly-compartment syndrome is a condition where two or more anatomical compartments have elevated compartmental pressures, and is classified into primary or secondary polycompartment.\(^\text{10}\)

Primary compartment syndrome is a rise of compartmental pressures that is pathological, with injury to physical tissue or the organ.\(^\text{10}\)

Secondary compartment syndrome occurs without the main injury to the involved compartment; symptoms are based entirely on pressure that is transmitted from a certain compartment to the other.\(^\text{10}\)

It is not a common syndrome to occur but has major consequences. There are 4 compartments in the body that are regarded as major; being the head, chest, abdomen, and extremities. The abdomen plays a crucial role in the development of compartment syndrome, as well as the effects of IAH have been described.\(^\text{10}\)

With the pathophysiology described there are also specific conditions mentioned in association with poly-compartment syndrome:
- Cardio-abdominal-renal syndrome or CARS
- Hepato-abdominal-pulmonary syndrome or HAPS
- And hepato-abdominal-renal syndrome or HARS

Different conditions precipitate the occurrence of poly-compartment syndrome\(^\text{10}\):
- Burns that are severe,
- Fluid resuscitation that is massive,
- Sepsis regarded as severe,
- Hypotension that is prolonged
There is therapeutic conflict with this syndrome; where decisions can cause harm. For example, with intracranial compartment syndrome; management involves decreasing intracranial pressure or raising Cerebral Perfusion Pressure (this done by adequate maintenance of MAP by using fluids or initiating vasopressors. Fluids used may worsen oedema in the viscera, result in ascites, and an increase in IAP; all leading to an increasing intrathoracic, internal jugular venous, as well as intracranial pressures [a vicious cycle]). The main treatment goal is to reduce the compartment pressure, plus improving organ function and decreasing mortality.

**ABDOMINAL COMPLIANCE**

Abdominal compliance (Cab) is a measure of the ease of abdominal expansion determined by the elasticity of the abdominal wall and diaphragm. It is expressed as the change in intra-abdominal volume per change in IAP, normal between 250-450 ml/mmHg.

It is difficult to measure Cab at bedside. Measurement can only be done when there is change, such as removal or addition in intra-abdominal volume (IAV). Identifying patients at risk for poor Cab by having the precise measurements or estimations; will help prevent the normal IAP progression to IAH and ACS, and avoiding complications.

A loss of elastic recoil of the abdominal wall is indicated by increased Cab. A decreased Cab means that IAP changed greater than IAV. Identifying patients with low Cab can help us with management plus choosing the suitable surgical procedure. The end result will be avoiding complications such as IAH or ACS.

Measurement of abdominal compliance involves the following:

a) **Intra-abdominal volume**
   It is difficult to measure intra-abdominal volume. IAV can be estimated using a three-dimensional ultrasound, water-suppressed breath hold magnetic resonance imaging, and computed tomography. It is not possible to always use these imaging techniques with ICU patients.

b) **Intra-abdominal pressure (IAP)**
   The technique to measure previously described (see pg 6).

c) **The abdominal tensiometer**
   It measures abdominal wall tension. The tensile strength is calculated using this formula below:
   \[
   \sigma_w = \frac{(P_i - P_o) R}{t}
   \]
   \(\sigma_w\) = stress in abdominal wall or tension
   \(P_i\) = internal pressure or IAP
   \(P_o\) = external pressure
   \(t\) = abdominal wall thickness and \(R\) = radius

d) **Pressure Volume (PV) relationship during laparoscopy**
   When there is volume added into the abdominal cavity; the compliance is decreased and the abdominal volume-pressure curve changes. Carbon dioxide is used to create a pneumoperitoneum and insufflated in the abdomen for laparoscopy. IAP and insufflated volume can be measured, and these are used to calculate the abdominal PV relationship (APVR).
Mulier et al. performed three successive studies during laparoscopy and the reason was to analyse the possible linear relationship (in most patients to a pressure of 20mmHg). This APVR part is related by an elastance \((E)\) and a pressure at zero volume \((Pv0)\). \(C = \text{compliance}\)^\textsuperscript{12,13}  

\[ E = 1 / C \]  
\[ \text{IAP} = E \times \text{IAV} + \text{Pv0} \]

**BURNS**

In severe burns; the incidence of IAH is around 50 to 70% with an incidence of ACS around 20 to 30%. Major burns management require large resuscitation fluid and poses a risk of IAH. IAP monitoring is necessary to detect patients at the highest risk, and measurement should be done during the phase of resuscitation as well as at that of recovery at least 4 to 6 times per day.

With the resuscitation endpoints; a decreased urinary output can easily mislead physicians, thinking it is the result of intravascular hypovolemia, when IAH and ACS can also be the cause. A vicious cycle occurs with further fluid loading.

![Figure 3](image)

*Figure 3* Sows the vicious cycle during resuscitation of burn shock.\textsuperscript{14}

Diuresis seen by clinicians may lead to fluid resuscitation being under estimated or overdone. Urine output is not recommended as the only endpoint anymore, and can still be used as a guide to fluid resuscitation where there is limited monitoring techniques.\textsuperscript{14}
MANAGEMENT

Prevention
Identify patients at risk early (those having multiple body cavity injuries, presenting with massive haemorrhage, and their physiological reserves nearly exhausted) and start damage control resuscitation (DCR).16, 17

The main components of DCR in trauma are16:

- Starting resuscitation early and maintaining circulation,
- Allowing permissive hypotension,
- To limit the use of crystalloids and to start using blood plus blood products early,
- Early use of Tranexamic acid

Vasopressors should be used and initiated early. DCR Part zero (DC 0) emphasizes early rewarming, and taking the patient to the operating theatre.16 Part one (DC I) begins in theatre with immediate exploratory laparotomy and the control of bleeding that should be done rapidly.16

Controversy with management of traumatic brain injury (TBI), a case report by Kohli et al concludes that TBI may be managed with permissive hypotension intra-operatively and appropriate monitoring of cerebral function such as cerebral oximetry should be present. In the conclusion of this report it was mentioned that more cases are required to be studied before guidelines can be formulated.18

Part two (DC II) continues with management at the intensive care unit, where the patient is stabilized physiologically and biochemically, thorough examinations are performed.16 Part three (DC III) is made up of re-exploration in theatre; repairing all injuries found, and occurs once physiology has normalized.16

Medical Management
1. Improve abdominal wall compliance
   - Sedation and analgesia:
     Has to be adequate so that the muscle tone is reduced, and to decrease IAP to less levels that can be harmful.4, 12, 19
     Remains unclear if alters outcome in patients with IAH/ACS.4
   - The use of neuromuscular blockers:
     Initiated after sedation and analgesia is provided for the patient.
     Reduces abdominal muscle tone, and increase abdominal compliance. Suggested as a temporizing measure and the benefits should be balanced against the risks of paralysis that may be prolonged.4, 12, 19 Usage should be monitored clinically and by the use of a nerve stimulator.
   - Body positioning:
     At higher levels of IAH, head elevation on the bed increases IAP as compared to supine positioning, and become significant clinically when 20° elevation is exceeded.4, 19
     Constrictive dressings must be removed, as well as abdominal eschars.

2. Evacuate intra-luminal contents
   - Nasogastric and colonic decompression:
     Minimise enteral nutrition.
     Nasogastric or rectal tubes are used for enteral decompression of the dilated stomach or colon when IAH/ACS is present.4, 12, 19
Promotility agents:
Metoclopramide and erythromycin used. Neostigmine usage is recommended for the treatment of an ileus (of the colon) associated with IAH, and not resolving with other forms of treatment that are simple. Its pharmacological effects was shown in a single RCT involving 21 patients, by Ponec et al. 1999, to be effective at colonic decompression induction.

Correct electrolytes derangement.

In patients with intra-peritoneal fluid, as evidenced by US and CT scan; Percutaneous decompression is a consideration.

3. Optimize fluid administration

Fluid balance among ICU patients:
A positive cumulative fluid balance has to be avoided in patients at risk of IAH/ACS, after completing the phase of acute resuscitation. Observational studies show that a negative fluid balance in patients with IAH seems to be associated with improved outcomes. Data from 23 studies suggested that mortality was reduced using deliberate attempts at conservative fluid management as compared to non-conservative fluid management.

Diuretics:
There were no recommendations made at the last consensus. It is unknown if diuretics improve outcome among those with IAH or ACS. Studies show improvement on patients with acute decompensated heart failure.

Renal replacement therapies:
It is used to modify fluid balance among critical ill patients; however no recommendations were made at the consensus. Improved survival rate is reported after RRT, especially when started on patients with acute renal failure that is severe.

Albumin:
No recommendations regarding its use were made, and there has been no randomised control trials studying its use on patients with IAH/ACS. The albumin 20% was recommended to be used in severe burns, more during the de-resuscitation phase. Its use is guided by indices such as capillary leak, weight of the patient, a positive fluid balance, extravascular lung water, fluid overload, and intra-abdominal pressure (IAP).

Damage control resuscitation:
Allows permissive hypotension for a short period (until bleeding controlled), limit the use of crystalloid intravenous fluids, encourage use of colloids and to administer blood products early.

Fluid management in burns

To prevent IAH/ACS we must aim to avoid fluid accumulation in these patients, and excess crystalloid administration by revising resuscitation protocols in our particular hospitals. The use of advanced hemodynamic monitoring should be done. The use of hypertonic saline is reported to reduce the risk for developing ACS, and avert administration of large fluid volumes to patients. Sodium levels should be monitored when the decision to use it is taken. The evidence gathered was insufficient to reach consensus regarding its safety for use during resuscitation in burns.

The use of colloids during resuscitation in burns is controversial. These are categorized as natural and semi-synthetic. The natural category for example, albumin or fresh frozen plasma, have limited use because of their cost.
The semi-synthetic category has major subclasses such as hydroxylethyl starches (HES), dextrans and gelatins. Hydroxylethyl starches are the most commonly used in this category.\textsuperscript{14} The CHEST trial, 6S and CRYSMAS trial conclusions have changed our practice regarding the use of HES.\textsuperscript{15} The use of HES solutions is indicated for acute hypovolemic shock, and their advantage was shown by the CRISTAL study done in 2013.\textsuperscript{28}

A prospective randomized trial by Michael S. O’Mara et al in 2005 showed the possibility to lower IAP significantly using plasma and comparing it to crystalloids.\textsuperscript{26} However, a 2014 systematic review by Strang et al noted that even though the effect of colloids reduced the needs of volume during resuscitation, there was no benefit observed on preventing IAH.\textsuperscript{27}

4. **Optimization of systemic and regional perfusion**

- Fluid resuscitation must be goal directed and monitoring of hemodynamics as mentioned is important.
- Actual gut perfusion is reflected by abdominal perfusion pressure, better than using IAP alone.\textsuperscript{4} If APP remains low despite fluid resuscitation; it is advised to start vasopressors to avoid development of acute renal failure.\textsuperscript{19} At the 2013 consensus the use of APP was not discussed as a recommendation during resuscitation of the critically ill nor injured, including the time of management for these particular patients.\textsuperscript{4}

**Surgical Management**

If IAP >20mmHg and is associated with organ dysfunction or failure that is new, patients with IAH or ACS refractory to medical management; the surgical decompression should be considered.\textsuperscript{4} Lesions identified by using ultrasound and CT scan should also be evacuated.\textsuperscript{4}

1. **Abdominal decompression**

- If medical therapy not working for patients with ACS; decompressive laparotomy should be considered. These patients must become first priority above stable ones and be taken for decompressive surgery in theatre as soon as possible. The surgery done immediately decrease IAP and result in improvements in organ function.\textsuperscript{4, 6} There are multiple complications associated with decompressive laparotomy and the mortality of patients is still significant.\textsuperscript{23}
- Management of the Open Abdomen is not that simple or without complications. This option is associated with a chance for having marked fluid loss, the possibility for sepsis, potential for perforation of the viscera, having organ dysfunction, and even lead to mortality.\textsuperscript{24}
- Temporary coverage of the abdomen is done using a Bogota bag (passive) or (negative pressure) using VAC (vacuum assisted closure). The use of VAC therapy after decompression from ACS, in comparison to Bogota bag, is reported to improve plus control intra-abdominal pressure early, decrease lactate levels to normal faster, and reduce the time taken to close the fascia. There is also early weaning of the ventilator, the days stayed in ICU and those in hospital are reduced.\textsuperscript{24}
- **Abdominal decompression in ICU done when:**
  - There is no available theatre
  - The patient is unstable
  - The patient unstable for transport to theatre
  - Too unstable to disconnect from the ventilator.
  Mortality still has to be expected with this option.\textsuperscript{25}
2. **Definitive abdominal closure**
   - With ICU patients: when the abdomen is open for a long period, there is a greater potential for morbidity to occur. The aim is to close the abdomen within a week.\(^4\)
   - During the treatment of critical illnesses amongst patients where an Open Abdomen was required for at least 48 hours, wound therapy with Negative pressure has been found to be associated with considerable higher 30-day Primary Fascial Closure rates, and a lower 30-day all cause mortality.\(^2\)

**CONTROVERSIES**

- Which method is the best to measure IAP?
- Should we rule out urine output measurements in burns patients?
- Permissive hypotension in head injury patient
- Does sedation alter outcome in IAH/ACS?
- Body positioning in association with VAP and Head injury patients
- Should we use synthetic colloids?
- Should more patients have open abdomen?

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**INTRA-ABDOMINAL HYPERTENSION (IAH) / ABDOMINAL COMPARTMENT SYNDROME (ACS) MANAGEMENT ALGORITHM**

![Algorithm Image](image)

**DEFINITIONS**

- IAH - intra-abdominal hypertension
- ACS - abdominal compartment syndrome
- IAP - intra-abdominal pressure
- APP - abdominal perfusion pressure (MAP-IAP)
- Primary ACS - A condition associated with injury or disease in the abdominal-pelvic region that frequently requires early surgical or interventional radiological intervention
- Secondary ACS - ACS due to conditions that do not originate from the abdominal-pelvic region

**Fig. 4 Updated 2013 algorithm for the management of intra-abdominal hypertension and abdominal compartment syndrome.**\(^4\)
IAP, IAH and ACS are topics and knowledge that is important to gain in our practice. We have to be aware of risk factors, complications, and aim for prevention. This can be achieved by monitoring IAP early, especially on critically ill, injured and burns patients. During management or patient care, judicious fluid administration plays an important role at prevention and the use of advance monitoring can help us reach that goal. Following algorithms by WSACS and our specific hospital protocols will ensure better treatment outcomes.
REFERENCES


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