Original Research Article

A Prospective Study to Measure Intra-Abdominal Pressure Following Emergency Exploratory Laparotomy And To Correlate It With Measurable Post-Operative Outcomes

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Abstract

Background: Several studies have documented the detrimental effects of Intra Abdominal Hypertension (IAH) and Abdominal Compartment Syndrome (ACS), however it remains largely under diagnosed. ACS is the end sequela of raised intra-abdominal pressure (IAP), defined as a sustained IAP >20 mmHg with or without an abdominal perfusion pressure <60 mmHg and associated with new organ dysfunction. **Objectives:** In this study my aim is to measure the intra abdominal pressures of patients following emergency exploratory laparotomy and to identify the presence of ACS and to see if there is any correlation between IAP measurements and major post operative outcomes. **Methodology:** 55 patients undergoing Emergency Exploratory Laparotomy.in the Department of General Surgery in Government Medical College, Kozhikode were studied. IAP was monitored at 0hrs, 6hrs, 12hrs, 24hrs, 48hrs and 72hrs post operatively and patient was monitored for development of complications and ACS. IAP was measured indirectly by measuring urinary bladder pressure using foleys catheter. **Results:** IAH was found to be a significant predictor for development of post operative cardiac, renal and respiratory complications. No significant association was found between IAP and occurrence of burst abdomen or wound related complications. Out of 55 patients studied 14 patients (25.5%) developed ACS. **Conclusion:** IAP is a significant predictor of mortality in patients undergoing emergency laparotomy. IAH has detrimental effects on various organ systems. A more frequent monitoring with prompt decompression may be helpful in decreasing the mortality rate.

Keywords: ACS, IAH, IAP.

Introduction

Compartment syndrome is a surgical emergency that is frequently mistakenly thought to only affect the limbs. It is crucial to understand that compartment syndrome can also occur within the abdomen because it is a limited chamber. Abdominal compartment syndrome (ACS) has only attracted the attention of the medical community since 1989. Since then, our understanding of ACS has grown. A variety of surgical and nonsurgical diseases, including as pancreatitis, burns, sepsis, and after aggressive fluid resuscitation, are now known to cause ACS to present. Early detection and intervention are critical to improving results.

Several studies have documented the detrimental effects of Intra Abdominal Hypertension (IAH) and Abdominal Compartment Syndrome (ACS), however it remains largely under diagnosed. For a patient who is already critically ill, abdominal compartment syndrome (ACS) can be fatal. Initially thought to only afflict surgical patients, ACS is now recognised in the context of the medical critical care unit. Death rates approach 70% as multiorgan failure occurs in the absence of quick and effective treatment. The World Society of Abdominal Compartment Syndrome (WSACS) published updated guidelines in 2012 to draw consensus and improve patient outcomes. [1] ACS is the end sequela of raised intra-abdominal pressure (IAP), defined as a sustained IAP >20 mmHg with or without an abdominal perfusion pressure <60 mmHg and associated with new organ dysfunction.

The IAP is the steady-state pressure within the abdominal cavity. It is dynamic, varying with respiration (increasing with inspiration and decreasing with expiration) and the intraabdominal volume. [1-5] IAP and intra-abdominal volume have a synergistic relationship. As the volume increases, whether it is occupied by solid organs, pathological masses or fluid, the compliance of the abdominal cavity reduces causing the IAP to increase. The normal IAP is 0e5 mmHg.[1-4] This increases to 5-7 mmHg in the critically unwell. [3-5]. Abdominal Perfusion Pressure is comparable to cerebral perfusion pressure. 2 It measures the abdominal blood flow pressure. It is the difference between the IAP and the mean arterial pressure.

Intra-abdominal hypertension (IAH) and ACS are the sequelae of sustained pathologically elevated IAP. IAH is defined as an IAP equal to or greater than 12 mmHg. IAH is further subcategorized into four groups based on increasing pressures (grade 1: IAP 12 -15 mmHg; grade 2: IAP 16 - 20 mmHg; grade 3: IAP 21 - 25 mmHg; and grade 4: IAP >25 mmHg). [3-5]

ACS is diagnosed when end organ dysfunction or failure occurs when the IAP is greater than 20 mmHg, with or without an APP less than 60 mmHg.[1-3,6] ACS can be further categorized into primary, secondary and recurrent. Primary ACS arises from injury or disease within the abdominopelvic cavity. Secondary ACS occurs as a result of conditions that originate from outside of the abdominopelvic cavity. Recurrent ACS is the persistence of ACS despite radiological or surgical management. [1,3,5] Irrespective of the subtype, the pathophysiology and clinical approach to ACS remains the same.

Most of the body systems are affected by ACS and IAH, most markedly the renal, respiratory, cardiac and nervous systems. The prognosis of the patient depends on the flow of the blood to various organs which are ultimately affected by ACS/IAH. Timely recognition and appropriate treatment of ACS/IAH, either medical or surgical, plays a very important role in reducing the morbidity and mortality of patients. [6]

When perfusion is depressed beyond a critical level, tissue viability is lost. The normal Intra-abdominal pressure is <7mmHg. Various conditions which ultimately lead to the accumulation of fluid, flatus or feces increase the intra-abdominal pressure and lead to intraabdominal hypertension first and later abdominal compartment syndrome. Injuries and diseases affecting the abdomino-pelvic region

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such as intestinal obstruction and peritonitis cause primary abdominal compartment syndrome; whereas diseases originating outside the abdomen such as sepsis and major burns leads to secondary abdominal compartment syndrome. The predisposing factors include conditions that results in reduced abdominal wall compliance (abdominal surgery, increased positive end expiratory pressure, acute respiratory failure, major burns, major trauma), increased abdominal contents (hemoperitoneum, pneimoperitoneum, acute pancreatitis, intra abdominal abscess etc), and increased capillary leakage and fluid resuscitation. [7]

The duration of IAH is of greater prognostic value than the absolute increase in IAP. The consequences of high IAP are exacerbated by certain pre-existing co-morbidities such pulmonary disease, chronic renal failure, or cardiomyopathy. This lowers the threshold of IAH, which results in the clinical manifestation of ACS. WSACS suggested screening for the IAP in critically ill patients admitted to the ICU [8].

There are no specific radiological features to identify abdominal compartment syndrome. This is one reason why CT scan is not used to diagnose a case of Intra-abdominal hypertension. However, radiological investigations may help to identify the cause, severity and the potential complications of the causative illness for the increased pressure and can also be used for guided aspiration or drainage of intra- abdominal collections. [9]

Intra abdominal hypertension and ACS can be prevented by regular measurement of IAP and optimising physiological parameters such as fluid balance, acid-base status, hemodynamic status, respiratory parameters among other factors. The IAP can be measured directly or indirectly, either intermittently or continuously. Direct measurement can be obtained by an intraperitoneal catheter installed for ascites drainage or peritoneal dialysis, an intraperitoneal pressure transducer and during laparoscopic surgery. Indirect methods for measuring IAP include intravesical, gastric, rectal, uterine, inferior vena cava and airway pressure measurements.

Several studies have shown that the incidence of IAH and ACS is significantly more when associated with sepsis and septic shock; it may be as high as 85% and 30% respectively. In cases of pancreatitis about 40-70% patients have been recognized to have IAH and 10-50% to have ACS. Post laparotomy incidence is variable but is generally low with elective surgeries and higher following emergency procedures.

Materials and Methods

Study design and settings

After obtaining approval from the institutional ethics committee a prospective study was conducted at the Department of General Surgery, Government Medical College, Calicut, Kerala, India.

Study Population

Patients undergoing emergency exploratory laparotomy in The Department of General Surgery, Government Medical college, Calicut.

Inclusion Criteria

All patients between 18-60 yrs of age undergoing emergency exploratory laparotomy from September 2021 to September 2022.

Exclusion Criteria

- Patients with previous established co-morbidities
- Re-laparotomies and those with previous history of abdominal surgeries.
- Patients with inoperable intra abdominal tumors
- Patients with bladder pathology
- Pregnant Females.

Data Collection and statistical analysis

From previous study (Analyzing intra-abdominal pressures and outcomes in patients undergoing laparotomy, International Surgery Journal, 2017), the sample size was calculated as 55. IAP of eligible candidates were measured indirectly by measuring the urinary bladder pressure with Foleys catheter. The bladder was drained and then filled with 50ml sterile saline through the foleys catheter. The tubing of the collecting bag was clamped and catheter was connected to saline manometer. The symphysis pubis was the zero reference and the pressure was measured in centimetres of water at end expiration. IAP was monitored at 0, 6, 12, 24, 48 and 72hrs post operatively. Laboratory investigations are done pre and post operatively and the values are monitored. Patients vitals and systemic examination along with urine output monitoring is done pre and post operatively. Patient is then monitored for development of complications like wound infections, burst abdomen, renal complications (RFT derangement, AKI, oliguria, Anuria, renal failure), pulmonary complications (pneumonia, ARDS, Atelectasis, respiratory failure), Cardiovascular complications (MI, AF, hypotension, shock, cardiac failure). A masterchart was prepared with the above collected data which was coded and entered in Microsoft Excel and statistical analysis was done using the software Statistical Package for Social Sciences(SPSS) using appropriate statistical tests.

Ethical consideration

The study was conducted after Institutional Research Committee & Institutional ethics committee clearance is obtained. Informed written consent will be obtained from participants. Subjects had full freedom to exit the study at any time. Patients did not have to bear any expenses for the study. Confidentiality was ensured and maintained throughout the study.

Results

The patients' age varied from 18 to 60 years (range - 42 years). The mean (SD) age of the participants was 46.87 (11.76) and median age was 48 years. More than 70% of the patients admitted for emergency exploratory laparotomy were males and 29% were females. Male to female ratio was 2.44. About 35% of patients underwent exploratory laparotomy with indication of acute intestinal obstruction followed by 29% for gastric perforation. 18% of patients underwent emergency exploratory laparotomy following trauma (including traumatic perforation). Six patients (11%) undergoing emergency exploratory laparotomy were for small bowel perforation and five patients (7%) had large bowel perforation on emergency exploratory laparotomy.

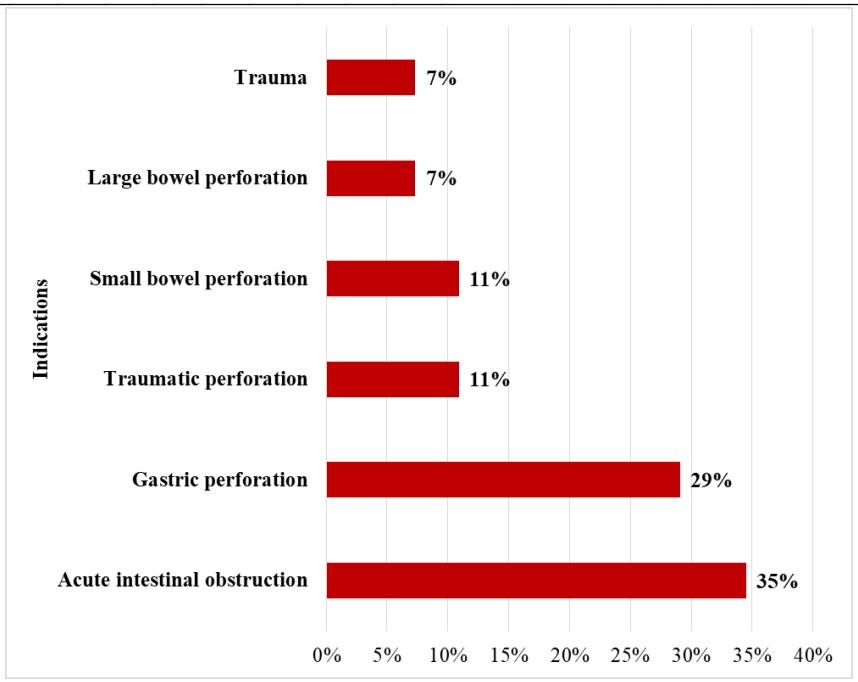

Figure 1: Distribution of participants based on indications for exploratory laparotomy (N=55)

The most prevalent incident complication the patient had after exploratory laparotomy was wound related complications (27.3%) followed by respiratory complications (25.4%). Half of the post exploratory laparotomy patients (50.9%) had at least one complication after surgery.

Table 1: Distribution of patients based on of presence of complications after surgery (N=55)

Complications	Frequency	Percentage
Wound related	15	27.3
Respiratory	14	25.4
Burst abdomen	10	18.2
Cardiac	6	10.9
Renal	5	9.1

14 (25.5%) out of the 55 post exploratory laparotomy patients developed abdominal compartment syndrome. All the 14 patients who developed ACS were underwent decompressive surgery. The mean IAP preoperatively was 23.37 mm Hg (3 days after initial laparotomy) and after surgery it reduced as 16.28 and the mean difference was statistically significant (p=0.000).

After the treatment course 43 patients (78.2%) got discharged from hospital and 12 (21.8%) patients expired during the treatment course in hospital. Out of the 12 patients who expired 7 patients had ACS and underwent Decompressive surgery. Out of 14 patients with ACS, 7 (50%) expired despite of decompressive surgery.

Table 2: Association between 24-hour post operative IAP and complications after surgery (N=55)

Complications		Intra-abdominal pressure		P value*
		≤20 mm Hg n (%)	>20 mm Hg n (%)	
Wound related	Absent	31 (77.5)	9 (22.5)	0.307
	Present	9 (60.0)	6 (40.0)	
Burst abdomen	Absent	34 (75.6)	11 (24.4)	0.434
	Present	6 (60.0)	4 (40.0)	
Cardiac	Absent	39 (79.6)	10 (20.4)	0.004
	Present	1 (16.7)	5 (83.3)	
Respiratory	Absent	39 (95.1)	2 (4.9)	0.000
	Present	1 (7.1)	13 (92.9)	
Renal	Absent	40 (80.0)	10 (20.0)	0.000
	Present	0	5 (100.0)	

*Fisher exact test

Prevalence of development cardiac, respiratory and renal complications was more among those with grade 3 or 4 intra-abdominal hypertension (IAP > 20 mm Hg) and these associations were statistically significant ($p < 0.05$). Post-operative IAP didn't show statistically significant association with occurrence of wound related complication or burst abdomen.

Table 3: Association between abdominal compartment syndrome and background characteristics (N=55)

Characteristics		Abdominal compartment syndrome		p value*
		Absent n (%)	Present n (%)	
Age (years)	< 48[a]	22 (91.7)	2 (8.3)	0.010#
	≥48	19 (61.3)	12 (38.7)	
Gender	Female	10 (62.5)	6 (37.5)	0.306
	Female	31 (79.5)	8 (20.5)	
Indication for surgery	Acute intestinal obstruction	10 (58.8)	9 (47.4)	0.010
	Perforation or trauma	31 (81.6)	5 (13.9)	
	>20	9 (39.1)	14 (60.9)	
Pulse rate	Normal	22 (100.0)	0	0.000#
	Tachycardia	19 (57.6)	14 (42.4)	
Systolic blood pressure (mm Hg)	≥ 90	38 (80.9)	9 (19.1)	0.020
	< 90	3 (37.5)	5 (62.5)	
Respiratory rate	Normal	35 (85.4)	6 (14.6)	0.003
	Tachypnoea	6 (42.9)	8 (57.1)	
SpO2 (%)	< 90	0	3 (100.0)	0.014
	≥90	41 (78.8)	11 (21.2)	
Urine output	Normal	41 (78.8)	11 (21.2)	0.014
	Reduced	0	3 (100.0)	

* Fisher exact test, # Chi square test, a – median age of participants, b – median duration after surgery

Among the fourteen patients who developed ACS majority were with age more than or equal to 48 years (38.7%), presented with acute intestinal obstruction (47.4%), tachycardia (42.4%), tachypnoea (57.1%), oxygen saturation less than ninety (100%) and reduced urine output (100%), and all these associations were statistically significant (p value < 0.05). Participants' gender did not have association with development of abdominal compartment syndrome.

Table 4: Association between abdominal compartment syndrome and outcome characteristics (N=55)

Characteristics		Abdominal compartment syndrome		p value*
		Absent n (%)	Present n (%)	
Duration of surgery (hours)	≤ two	17 (85.0)	3 (15.0)	0.178#
	> two	24 (68.6)	11 (31.4)	
Renal function	Normal	39 (86.7)	6 (13.3))	**0.000**
	Deranged	2 (20.0)	8 (80.0)	
Wound related complications	Absent	31 (77.5)	9 (22.5)	0.493
	Present	10 (66.7)	5 (33.3)	
Burst abdomen	Absent	34 (75.6)	11 (24.4)	0.703
	Present	7 (70.0)	3 (30.0)	
Death in hospital	Absent	36 (83.7)	7 (16.3)	**0.003**
	Present	5 (41.7)	7 (58.3)	

*Fisher exact test, # Chi square test

Patients with a deranged renal function had higher chance to develop ACS (80%) compared to those with normal renal function (13.3%) and this association was found to be statistically significant with a p value of 0.000. Patients who expired in hospital also were more likely to develop ACS and this also was statistically significant (p value 0.003). Out of the 12 expired during the course in hospital, 58.3% had developed ACS and it was also statistically significant. (p value 0.003). Duration of surgery and complications like burst abdomen or wound related complications didn't have any statistically significant association with development of ACS.

Discussion

In this study we measure the Intra abdominal pressures (IAP) in post emergency exploratory laparotomy patients and monitor the patients for development of intraabdominal hypertension (IAH) and abdominal compartment syndrome (ACS). The intra abdominal presssures were measured indirectly by measuring the urinary bladder pressure via perurethral foleys catheter.

This was a prospective study conducted in our institution and the study included patients who underwent emergency exploratory laparotomy. The study was conducted among 55 patients out of which 39 (71%) were males and 16 (29%) were females. A similar ratio was seen in the studies by Daga S et al (76% males), Hong et al (72% males), Meldrum et al (70% males) and Khan et al (76% males) (71–74). The mean ± standard deviation (range) of age in this study was 46.87 ±11.76 (range 18-60) years. Similar age distribution was seen in studies done by Daga S et al 43.6 ± 17.4 (range 18-80)years, Hong et al 42yrs years, Khan et al 35±15 years, Meldrum et al 39± 9 years Cheathum et al 51±19 years. [10-14]

Of the 55 patients who underwent emergency exploratory laparotomy, there were 10 (18%) trauma patients and 45 patients with indications other than trauma; most common being acute intestinal obstruction, 19 patients (35%). This is in contrast to the study conducted by Cheatum et al who had 68% trauma patients in their study group. Study by Khan et al and Daga S et al had a similar number of trauma patients (19% and 14% respectively).

The various complications observed following surgery, the most common being wound infection and wound related complications which attributed to about 27.3% of the complications, which was followed by the development of respiratory complications. Burst abdomen was seen in 18.2% of the patients. 10.9% and 9.1% of patients developed cardiac and renal complications respectively. About 30% of patients developed organ failure in the post operative period. The complication rates were much higher in this study when compared to the other studies.

In the studies conducted by Khan et al, Meldrum et al, Daga S et al

and Surgue et al [11,13-15] preoperative and postoperative IAP were monitored and a significant decrease in the pressures were noted post operatively. However in our study post operative IAP monitoring was done and it revealed progressive decrease in the IAP post operatively. The incidence of IAH in our study was 69% at 24hrs post op which was significantly on a higher side when compared to the study conducted by Daga S et al (8%). Out of the 15 patients who had IAP >20mm Hg 24hrs post operatively, 14(25.5%) patients developed newly detected organ dysfunction and were diagnosed to have ACS. The incidence of post op ACS in the study conducted by Daga S et was 1.9%. The study conducted by khan et al revealed post op ACS id 3.05% in general population, 13.16% in trauma patients and 0.63% in non trauma patients. The incidence of IAH and ACS reported by various studies ranges from 2-78% and 0.5-36% respectively and it depends on the population and values used to define these entities. [10]

Prevalence of development of cardiac, respiratory and renal complications were more among those with grade III and Grade IV IAH, however post operative IAH didn't show statistically significant association with occurrence of wound related complications or burst abdomen. Cheatham et al had found that elevated IAP alone does not have sufficient sensitivity or specificity to be used as a predictor of mortality. However in this study there was higher morbidity and mortality among patients who had IAH and ACS.

12 out of the 55 (21.8%) patients studied expired during the course of stay in the hospital.

Out of these 12 patients, 7 patients (58.3%) had ACS and expired despite of undergoing Decompressive surgery for the same. Out of 14 patients who developed ACS, 7 patient(50%) expired despite of Decompressive surgery. In a retrospective study of patients with secondary ACS, overall mortality was 60% with 43% mortality for those decompressed. [16] The studies conducted by khan et al, Hong et al, Meldrum et al and Ivatury et al [12,14,16] had a mortality of 100 %, 50%, 28.6% and 34.8% respectively in patients who developed ACS including patients who underwent Decompressive surgery. The mortality despite decompression could have been due to early fulminant MODS or delay in decompression. Hence, a more frequent IAP monitoring is recommended, at least in high-risk patients, as IAP measurement is simple and easy to perform. Also, it has high reproducibility and is minimally invasive. Delayed decompression has a high mortality rate indicating that a patient of ACS is salvageable only till the organ dysfunction is in the reversible phase.

Limitation of study- In this study the preoperative IAP was not measured for the patients and hence the change that developed post operatively could not be assessed.

Conclusion

Raised Intra Abdominal Pressure (IAP) is associated with high mortality and morbidity in patients undergoing emergency exploratory laparotomy. Intra abdominal hypertension(IAH) has detrimental effects on the various organ systems and decompression leads to improvement in all the parameters. Diagnosed cases of ACS had 58.3% mortality in this study despite of decompression hence early detection and early decompression before irreversible organ damage occurs is required to prevent mortality. Hence more frequent monitoring of IAP with prompt decompression is required to decrease the mortality and morbidity. In order to detect and manage cases of IAH and ACS after emergency laparotomy, further studies are required to establish a screening protocol in patients undergoing emergency exploratory laparotomy.

Conflict of Interest: Nil Source of support: Nil

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