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Intra-Abdominal Pressure – how Pressurizing is it?

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Abstract

Background: Increased intra-abdominal pressure (IAP) causes marked deficiency in both regional and global perfusion, resulting in significant organ failure, if unrecognized.

Aims & needs of the study :

- *To assess whether IAP is an independent predictor of morbidity & mortality .*
- *To evaluate presence of IAH & if present the effects on various organs .*
- *To detect hidden cases of abdominal compartment syndrome .*

Methodology: *This observational non-invasive prospective study was conducted over a period of 2 years from august 2017 to august 2019 and involved 66 study subjects. Patient co-morbidities, IAP, urine output and serum creatinine levels were documented postoperatively at 4 hourly intervals for 24 hours for patients undergoing major abdominal surgeries & emergency laparotomies. Data was analyzed by Chi-square test, Friedman test, t-test/Mann-Whitney U test, considering p≤0.05 as statistically significant.*

Results: *Majority of the patients had no co-morbidities. The mean IAP of patients who underwent laparotomy was 5.28±1.34 mmHg and that of MAS was 5.22±1.54 mmHg (p=0.82). A significant difference in the distribution of IAP at different time points with type of surgery (p=0.0001) was noted. The mean IAP of patients with normal urine output was 5.1±1.4 mmHg and for those with decreased output was 6.2±1.36 mmHg (p=0.04). The mean IAP who had undergone re-surgery was 6.9mmHg and who did not undergo re-surgery was 5.1mmHg.*

Conclusion: *Elevated IAP has been identified as a predictor of morbidity & likely implicator of mortality in our study with 3 of the 67-succumbing due to organ failure secondary to critical illness and likely plays a role in the development of multiple system organ failure. Routine measurement of IAP in patients at risk is essential to both recognizing the presence of Intra-Abdominal hypertension /Abdominal compartment syndrome and guiding effective treatment.*

Highlights:

- *Intra – Abdominal pressure (IAP) monitoring could help in earlier detection of morbidity & mortality.*
- *IAP is measured through the Intra – Vesical route.*
- *IAP monitoring could help the sick patient to return home from ICU earlier.*
- *IAP monitoring reduces the chance of patient falling critically ill as detecting of deterioration is much before clinical signs set in.*

Keywords :

- *Intra – abdominal pressure (IAP)*
- *Intra – abdominal hypertension (IAH)*
- *Abdominal Compartment syndrome (ACS)*

Introduction

Over the century, pathophysiologic association of increased intra-abdominal pressure (IAP) and various organs has been evaluated.[1] IAP is the steady-state pressure concealed within the abdominal cavity that is a result of interaction between the viscera and abdominal wall. IAP varies as per the abdominal wall resistance and respiratory phase.[2] Emerson in the year 1911 discovered the correlation between elevated IAP and morbidity, and mortality in patients with cardiovascular pathology.[3] However, recognising abdomen as a compartment and the phenomenon of intra-abdominal hypertension (IAH) causing abdominal compartment syndrome (ACS) is fairly new.

Although, IAP can physiologically reach up to 80 mmHg (Valsalva manoeuvre, cough, weightlifting, etc.), these values cannot be tolerated for long periods. Normal IAP is approximately 5–7 mmHg in adults who are critically ill. IAP >12 mmHg measured repeatedly or sustained elevation is termed IAH.

The presence of IAH is associated with a 11-fold increase in mortality in comparison to patients without IAH. The IAP may moderately progress to ACS, with a sustained IAP of >20 mmHg and associated organ failure or dysfunction.[2] In patients who are critically ill, IAH has been recognized as a cause of organ dysfunction, with renal and respiratory dysfunction being most prominent. IAH has been recognised as a continuance of pathophysiologic changes starting with regional blood flow disturbances and ending in frank end-organ failure along with ACS development.

Elevated IAP commonly causes marked deficiencies in both regional and global perfusion, resulting in significant organ failure leading to morbidity and mortality, if unrecognised.[4] Elevated IAP plays a crucial role in the progression of multiple system organ failure, that has plagued physicians and patients in the intensive care unit (ICU) for decades. Elevated IAP causes significant impairment of gastrointestinal, pulmonary, cardiac, hepatic, renal and central nervous system function.[4] ACS has most extensively been described in patients undergoing emergency abdominal surgery and in those with non-abdominal diseases such as massive fluid resuscitation and burns. ACS has been recognised as a significant cause concerning morbidity and mortality amongst critically ill medical, surgical, and paediatric patients. Previously present, but notably underappreciated, IAH and ACS are currently recognized as a common occurrence in the ICU setting. They have also shown to contribute to organ dysfunction and mortality in patients who are critically ill.[4] Diagnosis relies on IAP measurement, as clinical estimation and abdominal perimeter are poorly correlated with actual IAP.

Detrimental effects of IAH occur way before the manifestation of ACS. Prevalence of IAH is at least 50% in the critically ill population.[5] Despite it being recognised as an independent risk factor for death, majority of the critical care team members fail to assess for IAH and are unaware of the consequences that follow untreated IAH.[5,6] ACS should therefore be viewed because of progressive, unchecked rise in IAP from a myriad of disorders, eventually leading towards multiple organ dysfunction. Hence, the present study is proposed to evaluate the relationship between pre-operative IAP and post-operative morbidity and mortality in emergency & elective patients at a tertiary care centre in Bangalore, India.

Methodology

The study was done as an observational, prospective study involving patients who were hospitalised to a tertiary care centre in Bangalore from November 2017 to May 2019 undergoing major abdominal elective and emergency surgeries. Ethical clearance from the institutional research committee (SS-1/EC/037/2017) and written informed consent from the study subjects were acquired prior to the commencement of the study. Baseline characteristics, and clinical data were recorded from the study subjects.

The sample size was calculated based on the study conducted by Thirunavukkarasu and Maithreyi, where the mean intra vesicular pressure of patients who underwent laparotomy was reported as 16.6±4.16 mmHg.[7] Considering relative precision of 6% and desired confidence level of 95%, sample size for this study was estimated to be 66.

Inclusion Criteria:

The study included all the subjects undergoing emergency laparotomy or major abdominal surgery (MAS). Elective MAS are expected to last >2 hours and are observed to have a predicted blood loss >500 mL.

Exclusion Criteria:

Pregnant or lactating patients, patients <18 years of age, pre-existing chronic obstructive pulmonary disorder, coronary artery disease, renal failure, obesity, body mass index >35 kg/m2, hypertension, bladder disorders like neurogenic bladder and cystitis were excluded from the study.

A thorough case history was recorded and the treatment protocol was determined (emergency laparotomy or MAS). The IAP, urine output, serum creatinine levels and chest X-rays were documented. All the parameters were documented and associated with IAP, to signify its correlation with the patient condition and the treatment outcome. The measurements of IAP and urine output were recorded during the preoperative period and then postoperatively at 4 hourly intervals for 24 hours.

The preliminary details collected from patients included their names , age, sex, diagnosis, operative procedure planned, BMI. Presence or absence of co-morbidities like diabetes mellitus, hypertension were noted . General Examination findings of pulse, blood pressure, respiratory rate, temperature and specific systemic examination of respiratory system, cardiovascular system and abdomen were noted .

Laboratory tests done preoperatively and post operatively according to need were plasma urea, plasma creatinine and Chest X-Ray.

Clinical Measurement:

Intra-vesical route for measuring IAP was carried out by connecting the Foley's catheter to a 3-way tap which was then connected to a pressure transducer. The patient was placed in a supine position catheterized using a Foley's catheter and residual urine was drained. Later the Foley's catheter was clamped distal to a point of pressure measurement. IAP increased by 2 mm for every 20-degree head tilt. The catheter was tethered to a pressure transducer and the point of mid axillary line at the iliac crest was taken as reference point where IAP value was marked as zero. Around 25 ml was instilled into bladder, 30 to 60 seconds later the reading was taken, providing time for detrusor muscle relaxation.

All the measurements were taken close to expiration and absence of active abdominal muscle contraction. Foley's catheter was clamped before each measurement and a conversion factor of 1.36 was used to convert the pressure in centimetres of water into millimetre of Hg.

Data Analysis:

Data was analysed using statistical software R version 4.0.2. Categorical variables are presented in the form of frequency tables. Continuous variables were presented as mean ± standard deviation (SD) /median (range) form. Chi-square test was performed to analyze the association between categorical variables. Friedman test was performed to compare the distributions of variables between time points. To compare means, t-test/Mann-Whitney U test was performed. $p \leq 0.05$ was considered statistically significant.

During the period between 2017 & 2019 , 66 patients met the inclusion criteria . The mean age of patients undergoing emergency laparotomy (n=32) was 45.62±18.33 years and those undergoing MAS (n=34) was 54.58±16.95 years (Fig 1 A) . The mean IAP was used for comparison in this study .

IAH Is graded in 4 stages :

Grade 1 – 12 to 15 mmHg

Grade 2 – 16 to 20 mmHg

Grade 3 – 21 to 25 mmHg

Grade 4 – > 25 mmHg

Various causes for Major Abdominal Elective cases: Total Number = 34 cases

- Carcinoma colon – 7 (20 %)
- Carcinoma Stomach – 5 (14 %)
- Hernia – 6 (17 %)
- Cbd Pathology & - 4 (11 %)
- Ca ovary & Periampullary Carcinoma – 3 (9 %)
- Retroperitoneal Sarcoma – 2 (6 %)
- Others – 5 (14 %)

Various causes for Emergency cases: Total Number = 32 cases

1) TRAUMATIC

2) NON – TRAUMATIC

1) Traumatic: Total Number = 6 cases

- Blast injury – 2 (34 %)
- Spleen Injury – 2 (34 %)
- Spleen & liver Injury – 1 (17 %)
- Diaphragmatic rupture - 1 (17 %)

2) Non-Traumatic: Total Number = 26 cases

- Hollow Viscus perforation – 10 (40 %)
- Intestinal Obstruction - 4 (16 %)
- Strangulated Hernia – 4 (16 %)
- Superior mesenteric artery (SMA) occlusion – 2 (8 %)
- Others – 6 (20 %)

A total of 44 (66.7%) patients had no co-morbidities (Table 1 Subsection A). The mean IAP amongst the patients with co-morbidities (22 in number) was slightly higher than normal however there was no statistical significance noted. (Fig 1 B)

One (3.13%) patient underwent re-surgery for laparotomy and 5 (14.71%) for MAS. The mean IAP for the study participants who had undergone re-surgery was more than that of patients who did not undergo re-surgery and the mean difference was statistically significant. (p=0.005).

Urine output was normal for 26 (81.25%) and 31 (91.18%) patients who underwent laparotomy and MAS respectively. Similarly, the serum creatinine levels were normal for 25 (78.13%) and 30 (88.24%) patients who underwent laparotomy and MAS respectively.

Duration of surgery was significantly higher in MAS patients and lung pathologies were seen in significantly higher number of patients undergoing emergency laparotomy (p<0.05) (Table 1).

Variable		**Type of procedure - No. of Patients (%)**		***p*-value**
		Laparotomy (n=32)	**MAS (n=34)**	
A) Comorbidities	None	22 (68.75)	22 (64.71)	0.86
	HTN	6 (18.75)	5 (14.71)	
	DM	3 (9.38)	3 (8.82)	
	HTN+ DM	1 (3.13)	3 (8.82)	
	Others	0	1 (2.94)	
B) Chest X-ray	Normal	24 (75)	34 (100)	0.004*
	Atelectasis	3 (9.38)	0	
	Pleural effusion	5 (15.63)	0	
C) Duration of surgery (in mins) (median, IQR)		150 (80, 300)	182.5 (85, 600)	0.01*
D) Duration in ICU	< 3 days	27 (84.38)	24 (70.59)	0.18
	3-6 days	5 (15.63)	10 (29.41)	

Table 1: Comparing study variables between groups

*Significant (p<0.05). Abbreviations: DM, diabetes mellitus; HTN, hypertension; ICU, intensive care unit; IQR, inter-quartile range; MAS, major abdominal surgery.

The mean IAP of patients <60 years old (n=44) was 5.19±1.36 mmHg and those ≥ 60 years old was 5.35±1.63 mmHg (Fig. 1A). The mean IAP of patients who underwent laparotomy was 5.28±1.34 mmHg and that of MAS was 5.22±1.54 mmHg (p=0.82) (Fig. 1C).

A significant difference was noted in the distribution of IAP at different time points with type of surgery (laparotomy, p=0.0001; MAS, p=0.0001) (Fig. 1D).

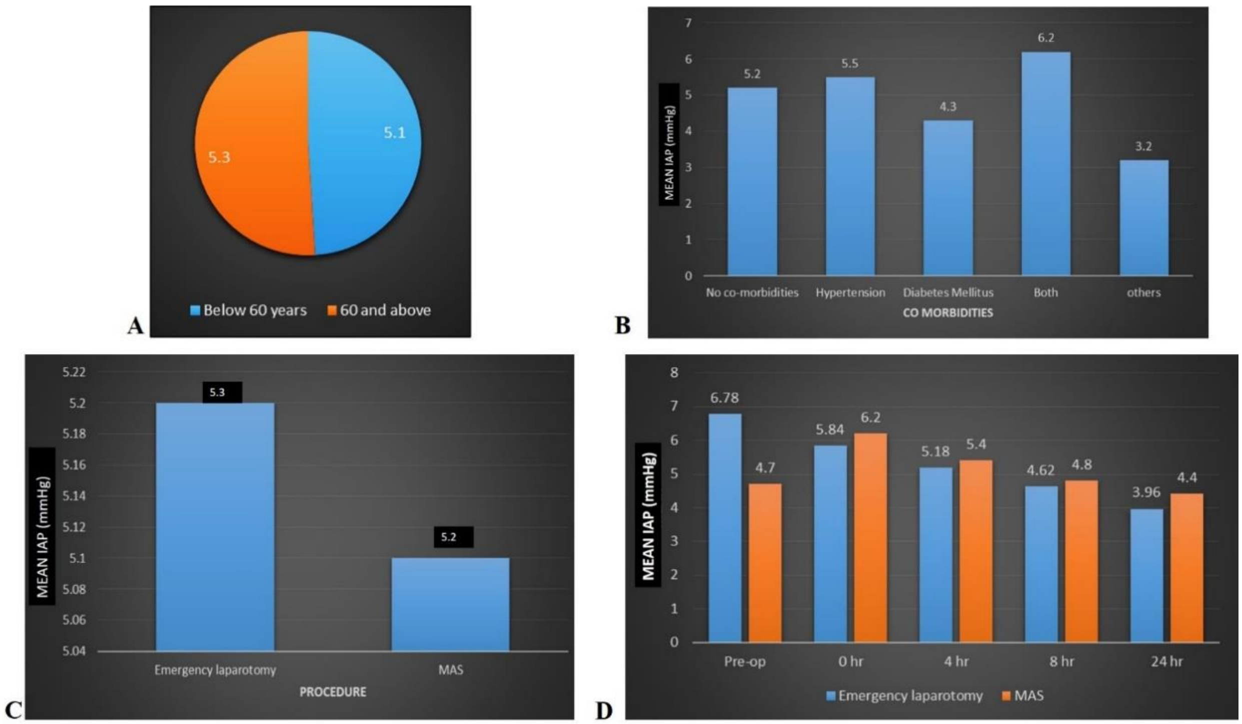

Figure 1: Mean IAP of patients with respect to (A) age, (B) co-morbidities, (C) type of surgery and (D) different operative time points.

Abbreviations:

IAP, intra-abdominal pressure;

MAS, major abdominal surgery.

The mean IAP of patients with normal urine output was 5.1±1.4 mmHg and for those with decreased output was 6.2±1.36 mmHg. The difference in the distribution of mean IAP with urine output was significant (p=0.04).

The mean IAP of patients with normal serum creatinine levels was 5.19±1.45 mmHg and for those with deranged levels was 5.53±1.41 mmHg. The difference in the distribution of mean IAP with serum creatinine was insignificant (p=0.4).

The difference in the distribution of mean IAP with chest X-ray findings was insignificant (p=0.2) (Fig. 2).

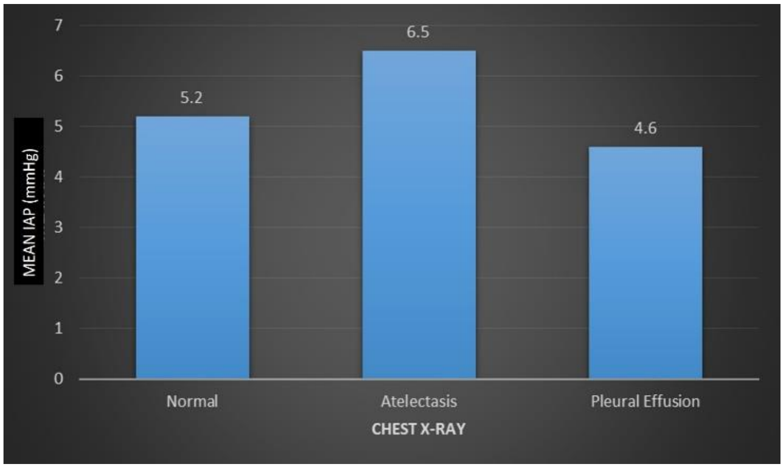

Figure 2: Mean IAP of patients with respect to chest X-ray findings

Abbreviations:

IAP, intra-abdominal pressure

The mean IAP of patients who stayed in the ICU for <3 days was 4.99±1.45 mmHg, and for those who stayed for 3-6 days, it was 6.12±1.02 mmHg. The difference in the distribution of mean IAP with duration of stay at the ICU was significant (p<0.004) .

The mean IAP of patients who underwent re-surgery for both procedures was 6.93±1.58 mmHg and for the rest of them was 5.1±1.32 mmHg (p = 0.05) & hence is was statistically significant.

Discussion

According to a study done by Khan et al., IAP significantly predicts mortality but not morbidity in laparotomy patients.[10] A scientific investigation and collection of clinical experience confirmed the significant deleterious impact of increased IAP , IAH-induced organ-dysfunction and failure amongst the critically ill.[4] In the 2013 consensus guidelines for clinical practice, the World Society of Abdominal Compartment Syndrome recommended measuring of IAP in all ICU patients with high risk of developing IAH.[8] The present study evaluated the effect of IAP on morbidity and mortality outcomes in patients undergoing emergency laparotomy or MAS.

The pre-operative mean IAP in patients undergoing emergency laparotomy was higher in comparison to post-operative IAP which could be attributed to the nature of illness requiring emergency management & decrease in IAP in this group could be correlated to timely surgical intervention.

Mean IAP in patients undergoing emergency laparotomy was higher and the difference in the distribution of IAP at different time points with type of surgery was significant. The pre-operative mean IAP in patients undergoing emergency laparotomy was higher in comparison to post-operative IAP which could obviously indicate that a surgical intervention was required.

In patients undergoing MAS, the highest mean IAP was noted at 0 hr though the IAP measured did not point to IAH / ACS for that matter. In our study we had 2 patients with Grade 1 IAH post – operatively and what we found out was that

- Detecting the presence of Raised IAP due to early IAP measurements, reducing the elevated IAP and restoring end-organ perfusion by the application of comprehensive medical management strategies or timely surgical abdominal decompression could help in reduction of the IAP and hence improvement of the patient earlier as seen by their hospital stay , X ray changes and of course their Renal function tests as Renal function is the first to deteriorate amongst all organ systems .
- Surgical decompression for refractory organ dysfunction and attempting at fascial closure at an earlier stage once physiologically appropriate may be few reasons to control IAP.[4] These strategies have been earlier demonstrated to significantly reduce complication, decrease resource utilization and improve patient survival.[9]

Elevated IAP causing multiple derangements in both intra- and extra-abdominal organs are well documented.[10] The difference in the distribution of mean IAP with urine output was significant ($p=0.04$). Similar results were reported in a previously conducted study ($p<0.01$).[11] Patients with increased IAP experienced decreased urine output as high IAP could lead to intrarenal venous congestion and thereby resulting in the reduction of glomerular filtration rate.[12] Patients with higher IAP had deranged serum creatinine and the difference in the distribution of mean IAP with serum creatinine was insignificant.

In case of critical illness, elevated IAP is identified as an independent predictor of mortality, playing a major role in terms of multiple system organ failure that has plagued ICU patients and physicians for decades.[4] In our study, only patients having elevated IAP were in the ICU for 3-6 days. Significant decrease in morbidity and mortality could be attributed to the early recognition and diagnosis of IAH in addition to appropriate therapeutic scheme.[13] Despite the abundance of knowledge, IAP or IAH still remains underdiagnosed and hence appropriate measures must be taken at earlier stages to prevent patient morbidity.

Limitations

Smaller sample size. Additionally, postoperative pain was not evaluated amongst the patients. Monitoring IAP frequently with prompt decompression may be advantageous in decreasing mortality rate. Future studies are suggested soon to arrange proper screening protocol in laparotomy patients to detect and manage IAH and ACS.

Conclusion

It is vital to spread awareness about IAH and ACS and hence the involvement of health care workers whether it is nursing facility , resident doctors , specialists etc in the measurement of IAP as a routine procedure in patients who have high probability either due to their underlying co – morbid conditions or due to surgery itself , be it major surgeries or emergencies is imperative.

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