Role of intra-abdominal pressure measurement in patients with acute abdomen requiring exploratory laparotomy

Introducțion: Acute abdomen is one of the most common surgical emergencies faced by a surgeon. Monitoring Intra-Abdominal Pressure (IAP) in patients with acute abdomen referred for exploratory laparotomy may help guide the need for early intervention.

Aim: This study was performed to determine whether preoperative IAP had any significant association with organ failure as assessed using SOFA score. Furthermore, effect of IAP on patient outcome in terms of hospital stay, mortality was also evaluated.

Materials and methods: 60 patients above 18 years of age presenting with acute abdomen requiring exploratory laparotomy were included in this prospective observational study from November 2013 until March 2015. IAP and SOFA scores were calculated at the time of admission. The outcome of patients was assessed in terms of hospital stay, morbidity and mortality. The correlation between IAP and SOFA scores was also assessed to determine the risk of organ failure. The inferences were drawn with the use of SPSS v22.0 statistical software. ANOVA, Chi-square and Student’s t-test were used in the analysis.

Results: There was a positive correlation between SOFA score and IAP, and this correlation was found to be statistically significant with Pearson’s correlation coefficient being 0.6247 and significance levels being <0.0001. Both hospital stay and mortality positively correlated with the degree of IAP.

Conclusions: IAP should be routinely measured in patients with acute abdomen requiring exploratory laparotomy. Patients with preoperatively raised IAP should be referred for emergency surgery as soon as possible for better outcome.

KEYWORDS: acute abdomen, exploratory laparotomy, intra-abdominal hypertension (IAH), intra-abdominal pressure (IAP), SOFA score

INTRODUCTION

Acute abdomen is one of the most common surgical emergencies faced by a surgeon. Monitoring Intra-Abdominal Pressure (IAP) in patients with acute abdomen referred for exploratory laparotomy may help guide the need for early intervention. In most surgical centers this aspect is underappreciated and routine measurement of IAP is generally not practiced.

In a healthy person IAP varies from 0 to 5 mmHg in an inverse relationship with intra-thoracic pressure during normal breathing. Mean IAP in critically ill adults is approximately 5–7 mmHg [1–3]. IAP >12 mmHg is defined as IAH. Abdominal compartment syndrome is present when IAP is sustained beyond 20 mmHg with or without abdominal perfusion pressure <60 mmHg with at least one end organ failure [2, 4–7].

Risk factors for development of IAH include closed incisions after lengthy abdominal surgery with large volume of intravenous fluid being administered, peritonitis, severe abdominal trauma, bowel obstruction, pelvic fracture, burns, acute pancreatitis, intra-abdominal hemorrhage, retroperitoneal hematoma and surgical closure under excessive tension [1].

High intra-abdominal pressure leads to diminished venous return, reduced cardiac output, and respiratory failure. Respiratory failure can result from high inspiratory pressure, which can lead to hypoxia and reduction in pulmonary compliance. Loss of renal function is indicated by oliguria or anuria due to reduced renal blood flow and reduced glomerular filtration rate. Intra-abdominal hypertension also results in reduced mesenteric and mucosal blood flows. All these pathophysiological changes can lead to multiorgan dysfunc-

World Society of Abdominal Compartment Syndrome (WSACS) has developed grading of IAH [4–6]:

- Grade 0: < 12 mmHg;
- Grade 1: 12–15 mmHg;
- Grade 2: 15–20 mmHg;
- Grade 3: >20 mmHg.

Risk factors for development of IAH include closed incisions after lengthy abdominal surgery with large volume of intravenous fluid being administered, peritonitis, severe abdominal trauma, bowel obstruction, pelvic fracture, burns, acute pancreatitis, intra-abdominal hemorrhage, retroperitoneal hematoma and surgical closure under excessive tension [1].

High intra-abdominal pressure leads to diminished venous return, reduced cardiac output, and respiratory failure. Respiratory failure can result from high inspiratory pressure, which can lead to hypoxia and reduction in pulmonary compliance. Loss of renal function is indicated by oliguria or anuria due to reduced renal blood flow and reduced glomerular filtration rate. Intra-abdominal hypertension also results in reduced mesenteric and mucosal blood flows. All these pathophysiological changes can lead to multiorgan dysfunc-

World Society of Abdominal Compartment Syndrome (WSACS) has developed grading of IAH [4–6]:

- Grade 0: < 12 mmHg;
- Grade 1: 12–15 mmHg;
- Grade 2: 15–20 mmHg;
- Grade 3: >20 mmHg.

Risk factors for development of IAH include closed incisions after lengthy abdominal surgery with large volume of intravenous fluid being administered, peritonitis, severe abdominal trauma, bowel obstruction, pelvic fracture, burns, acute pancreatitis, intra-abdominal hemorrhage, retroperitoneal hematoma and surgical closure under excessive tension [1].

High intra-abdominal pressure leads to diminished venous return, reduced cardiac output, and respiratory failure. Respiratory failure can result from high inspiratory pressure, which can lead to hypoxia and reduction in pulmonary compliance. Loss of renal function is indicated by oliguria or anuria due to reduced renal blood flow and reduced glomerular filtration rate. Intra-abdominal hypertension also results in reduced mesenteric and mucosal blood flows. All these pathophysiological changes can lead to multiorgan dysfunc-

World Society of Abdominal Compartment Syndrome (WSACS) has developed grading of IAH [4–6]:

- Grade 0: < 12 mmHg;
- Grade 1: 12–15 mmHg;
- Grade 2: 15–20 mmHg;
- Grade 3: >20 mmHg.

Risk factors for development of IAH include closed incisions after lengthy abdominal surgery with large volume of intravenous fluid being administered, peritonitis, severe abdominal trauma, bowel obstruction, pelvic fracture, burns, acute pancreatitis, intra-abdominal hemorrhage, retroperitoneal hematoma and surgical closure under excessive tension [1].

High intra-abdominal pressure leads to diminished venous return, reduced cardiac output, and respiratory failure. Respiratory failure can result from high inspiratory pressure, which can lead to hypoxia and reduction in pulmonary compliance. Loss of renal function is indicated by oliguria or anuria due to reduced renal blood flow and reduced glomerular filtration rate. Intra-abdominal hypertension also results in reduced mesenteric and mucosal blood flows. All these pathophysiological changes can lead to multiorgan dysfunc-

World Society of Abdominal Compartment Syndrome (WSACS) has developed grading of IAH [4–6]:

- Grade 0: < 12 mmHg;
- Grade 1: 12–15 mmHg;
- Grade 2: 15–20 mmHg;
- Grade 3: >20 mmHg.
Foley’s catheter was introduced. Patient had to lie still during the entire procedure and could not be agitated or restless. Urinary catheter was raised above the patient, allowing a U-loop to form. The connection site was levelled (to zero level), where the catheter meets the drainage tube in midaxillary line at the level of the anterior superior iliac spine in a completely supine patient. 25 ml normal saline was instilled into an empty bladder and before any measurement was made, the oscillation test was performed to confirm the patency of the fluid column from bladder to manometer. After a period of equilibrium of about 60 seconds, fluid column was allowed to settle and measurement was taken from zero connection to the meniscus of the fluid column using a centimeter ruler. IAP was calculated by the following equation – IAP = IAP (cm of normal saline)/1.36.

SOFA score was also calculated in the preoperative period. Subsequently, patients underwent emergency surgery. In the post-operative period they were kept under close monitoring. Patients received intravenous broad spectrum antibiotics (Ceftriaxone 1g BD and Metronidazole 500 mg/100 ml TDS), analgesics and i.v. fluids. They were encouraged to do exercise spirometry and chest physiotherapy. Early mobilization and early enteral feeding depending on the bowel movements were also promoted. Patient outcome was evaluated in terms of duration of hospital stay and mortality.

**MATERIALS AND METHODS**

This prospective observational study was conducted from November 2013 to March 2015 at the Department of Surgery, Atal Bihari Vajpayee Institute of Medical Sciences and Dr. Ram Manohar Lohia Hospital, New Delhi, India.

Inclusion criteria: A total of 60 patients above 18 years of age presenting with acute abdomen requiring exploratory laparotomy were included in the study.

Exclusion criteria: Patients with contraindications to intravesical pressure measurements, such as pelvic fractures, hematuria, neurogenic bladder or patients with past surgery on the urinary bladder and all pregnant women were excluded from the study.

Sample size was calculated and considered according to the previous study [11] with \( p = 5\% \) and \( d = \text{absolute error of } 5\% \).

Hospital Ethical Committee approval was. All the patients included in the study gave their informed consent. A predesigned template was made and the clinical data of all the patients were recorded. All patients were adequately resuscitated with crystalloids. They all received broad spectrum antibiotic (Ceftriaxone 1g i.v.). Arterial Blood Gas analysis and serum electrolyte levels were performed in all the cases.

IAP measurement and SOFA score calculation were performed before exploratory laparotomy.

IAP of each patient was measured using a urinary catheter and a manometer as per recommendation of WSACS. IAH grading was then calculated using the values formulated by WSACS.

IAP was measured with patient laid down flat in supine position.

<table>
<thead>
<tr>
<th>Tab. I. Frequency distribution of patients according to the length hospital stay and IAP grading and correlation between those variables.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HOSPITAL STAY (DAYS)</strong></td>
</tr>
<tr>
<td><strong>GRADE 0</strong></td>
</tr>
<tr>
<td>0–5</td>
</tr>
<tr>
<td>6–10</td>
</tr>
<tr>
<td>11–15</td>
</tr>
<tr>
<td>16–20</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tab. II. Frequency distribution of preoperative SOFA subscores.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SOFA SUBCATEGORY</strong></td>
</tr>
<tr>
<td>Respiratory System</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Coagulation System</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Renal System</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>CNS System</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Hepatic System</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>CVS System</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

SOFa score was also calculated in the preoperative period. Subsequently, patients underwent emergency surgery. In the post-operative period they were kept under close monitoring. Patients received intravenous broad spectrum antibiotics (Ceftriaxone 1g BD and Metronidazole 500 mg/100 ml TDS), analgesics and i.v. fluids. They were encouraged to do exercise spirometry and chest physiotherapy. Early mobilization and early enteral feeding depending on the bowel movements were also promoted. Patient outcome was evaluated in terms of duration of hospital stay and mortality.
In addition to the above outcomes, correlation between the grade of IAH and the presence of organ failure (calculated using SOFA score in preoperative period) was also evaluated.

**Statistical Analysis**

Statistical analysis was performed using SPSS v22.0 statistical software. Data was represented as means ± SD. Continuous variables were compared using Student’s t-test. Correlation between two continuous variables was established using Pearson’s correlation coefficient. The p-value <0.05 was considered significant.

**RESULTS**

The study included a total of 60 patients. 12 of them were female and 48 were male. Majority of patients were under the category of acute peritonitis secondary to intestinal perforation (n = 25) followed by acute intestinal obstruction (n = 18), pyoperitoneum (n = 9) and blunt trauma abdomen (n = 8).

**Frequency distribution of patients according to IAP**

Of 60 patients included in the study, 37 (61.1%) had IAP below 12 mmHg and 23 (38%) patients had IAP ≥12 mmHg.

According to IAP grading, 17 patients (28.3%) were in grade 1, 5 patients (8.33%) in grade 2, and 1 patient (1.67%) was in grade 3. In the present study there were no patients with grade IV IAP.

**Frequency distribution of patients according to associated comorbidities**

Four patients had diabetes mellitus, of which 3 had IAP below 12 mm Hg. Only one diabetic patient had grade 2 IAH. There was one patient with arterial hypertension in our study. His IAP was below 12 mm Hg.

**Frequency distribution of patients according to the diagnosis and grade of IAP grade**

Twenty-five patients in the study had acute peritonitis secondary to intestinal perforation. Among that group, 15 patients (60%) had IAP <12 mmHg and 10 patients (40%) had IAP ≥12 mmHg. Of those 10 patients, 6 had grade 1 IAH, 3 had grade 2 IAH and 1 patient had grade 3 IAH.

Acute intestinal obstruction constituted the second largest group in the study (18 patients). Of those, 8 patients had IAP <12 mmHg and 10 patients had IAH (IAP ≥12 mmHg) with 8 subjects with grade 2 IAH and 2 with grade 2 IAH.

Nine patients in the study had pyoperitoneum causing peritonitis. Only 2 out of those 9 patients had raised IAP (≥12 mmHg).

Out of 8 patients with blunt abdominal trauma requiring exploratory laparotomy, only 1 patient had raised IAP (≥12 mmHg).

Student’s t-test was used to find the relationship between the IAH grading and the diagnosis, which was found to have no statistical significance (p value = 0.519).

**DISCUSSION**

Many past studies have searched for the correlation between raised IAP and the risk of organ failure. Correlation between IAP with hospital stay and mortality has also been demonstrated. These studies were mainly performed either in critically ill Intensive Care Unit patients or in patients with acute abdomen, such as acute pancreatitis. Despite a thorough search, we could
not find were any studies demonstrating the causative role of IAP in the development of organ failure or its association with postoperative hospital stay and mortality in patients requiring exploratory laparotomy.

In this study, out of 60 patients, 25 had intestinal perforation, 18 intestinal obstruction, 9 pyoperitoneum and blunt trauma to the abdomen was present in 8 patients. Elevated IAP (Grade I/II/III) was identified in 23 of 60 patients.

Preoperative IAP values were also compared with SOFA scores, which were also calculated preoperatively. An increase in the SOFA score was found with an increase in IAP values. This positive correlation was found to be statistically significant with Pearson’s Correlation factor 0.6247 and significance levels $<0.0001$. This was also corroborated by studies conducted by Malbrain et al. [12] and Vidal et al. [13]. Malbrain et al. [12] in their study showed that IAH/IAP affects 30–50% of all ICU patients and acts as an independent risk factor for multiple organ failure and mortality. Vidal et al. [13] in their study conducted on surgical-medical ICU patients concluded that a positive correlation exists between elevated IAP and raised SOFA score.

In our study, in 12 patients hospital stay lasted $\leq$ 5 days, in 34 patients 6–10 days from admission and 14 patients stayed in the hospital $\geq$ 11 days. In other words, only 3 out of 37 patients (8.10%) with normal IAH stayed in the hospital $\geq$ 11 days, whereas 11 out of 23 patients (47.82%) with IAH stayed $\geq$ 11 days. We also found that duration of hospital stay positively correlated with the grade of IAH and this correlation was statistically significant (p value $<0.005$). Similar results were obtained by Santa-Teresa et al. [14] in their study conducted on 151 patients. They also concluded that raised IAP leads to increased duration of hospital stay.

As far as patient outcome is considered in terms of mortality, 9 of 60 patients included in our study have died. One of those 9 patients had normal IAP, while 4 had grade 1 IAH, 3 grade 2 IAH and 1 grade 3 IAH. There was only 1 death among patients with normal IAP (n = 37; 2.7%), whereas mortality rate was 34.78% (8/23) among patients with IAH. This relationship between IAP grade and mortality was found to be statistically significant with p value $<0.05$. Similar results were obtained by Sadeghi et al. [15] in their study on 25 patients. They also concluded that elevated IAP was significantly associated with raised mortality. Marcos Neira et al. [16], in their study on 374 patients, also found increased mortality with raised IAH. Lang et al. [17], in a study on 491 patients, found a positive, statistically significant correlation between mortality and raised IAH.

CONCLUSION

This study demonstrated that in patients with acute abdomen requiring exploratory laparotomy, elevated IAP resulted in increased risk of organ dysfunction/failure, prolonged hospital stay and greater mortality. IAH is a significant clinical problem in patients with acute abdomen requiring exploratory laparotomy, with high prevalence, as evidenced by our study. IAP is one of the many factors responsible for patient outcome after exploratory laparotomy in acute abdomen. Results need to be corroborated by a multivariate analysis in order to take into consideration confounding factors, such age, comorbidities, and immunocompromised status. As a take home message from this study, it can be stated that IAP should be routinely measured in patients with acute abdomen requiring exploratory laparotomy. Patients with acute abdomen and preoperatively raised IAP should be candidates for emergency surgery as soon as possible in order to improve their outcome before deleterious effects of raised IAP on various organ systems set in. IAP can also be used as a prognostic tool for patients with raised values, as it is associated with poor outcome.

REFERENCES

The authors declare that they have no competing interests.