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CLINICAL STUDY OF INTRA-ABDOMINAL PRESSURE IN PATIENTS WITH ACUTE ABDOMINAL CONDITIONS: A PROSPECTIVE STUDY.

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Abstract

Objectives

This study explores the connection between elevated pressure within the abdominal cavity and the onset of acute abdomen, aiming to understand its prevalence, effect on functioning of organ, and the efficacy of early interventions for improved patient outcomes.

Methods

The study, conducted in the Department of General Surgery of Indira Gandhi Institute of Medical Sciences (IGIMS) in Patna, Bihar, India, between January 2022 to December 2023 enrolled 150 participants diagnosed with acute abdomen based on specific criteria. Following WSACS guidelines, intra-abdominal pressure (IAP) measurements categorized patients into normal and elevated IAP groups, further unveiling distinct intra-abdominal hypertension (IAH) subgroups. Utilizing IBM SPSS and Statistica, the statistical analysis explored correlations, group differences, and regression, offering valuable insights into the impact of IAH on patient outcomes.

Results

The study consisted of 150 acute abdomen patients, in which those with intra-abdominal hypertension (IAH) (n=90) showed a significant mortality rate of 40%, compared to 22.5% in the normal pressure group (n=60). Stratifying IAH patients by IAP levels revealed distinct mortality rates: 29%, 35%, 50%, and 80% in the four groups respectively. Statistical analyses revealed prominent correlations between mean IAP and key clinical parameters, including an extremely strong positive correlation between APP and FG. The trends depicted a gradual increase in SOFA score and CVP values with rising IAP levels, peaking in the fourth group.

Conclusion

The study highlights the significant effect of IAH on organ perfusion and patient outcomes in acute abdomen. These findings underscore the importance of early recognition and targeted interventions to improve prognosis and reduce mortality.

Recommendation

The study recommends implementing proactive measures for early detection and management of IAH in acute abdomen to enhance patient outcomes.

Keywords: *Intra-abdominal hypertension, Acute abdomen, Prognostic factors, Organ perfusion*
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Introduction

In the context of various medical conditions such as sepsis, burns, extensive fluid resuscitation, and bowel obstructions following major abdominal surgery or peritonitis, the emergence of abdominal compartment syndrome (ACS) and intra-abdominal hypertension (IAH) presents a formidable challenge [1-4]. Notably, acute abdomen has been identified as a condition intricately linked to the pathophysiological development of IAH, with studies revealing its significant impact on organ systems and heightened rates of fatality in cases where ACS manifests with no indication of infection [5-8]. Addressing this concern, early decompression of the abdomen has been proposed as a crucial intervention.

Extensive investigations into the association between IAH and acute abdomen have shed light on the underlying pathophysiological mechanisms, the adverse implications for disease progression, and strategies to mitigate elevated intra-abdominal pressure (IAP) [9-12]. IAH has now emerged as a valuable prognostic marker for evaluating the intensity of abdominal illness, like acute abdomen, exerting a considerable influence on the disease's course and eventual outcomes [13, 14]. The Abdominal Compartment Society reports a substantial incidence of IAH (60%) and ACS (27%) in patients with acute abdomen, with a noteworthy 70% already exhibiting IAH upon admission [15]. Furthermore, the persistence of IAH has been linked to ACS development and subsequent dysfunction of organ, leading to elevated fatality rates [16].

Investigations guided by revised definitions from the World Society of the Abdominal Compartment Syndrome (WSACS), have underscored a higher prevalence of IAH [17, 18]. This highlights the imperative need for early IAP

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measurement upon admission to enable timely interventions aimed at reducing intra-abdominal pressure. Within a mixed ICU setting, findings revealed a significantly higher prevalence of IAH, with 30% of individuals presenting intra-abdominal hypertension on hospitalization and an additional 15% developing it in the initial 5 days [17]. This trend was particularly pronounced among patients with sepsis, underscoring the importance of both monitoring and direct surgical interventions in the management of IAH.

The pathway leading to acute abdomen involves systemic microvascular dysfunction, resulting in vascular leak and substantial fluid sequestration in the third space, mirroring patterns seen in critical illnesses. Elevated IAP, which leads to pressure on adjacent organs hampers their function, causing the early degradation of organ system. Recognizing the significance of monitoring changes in essential life function parameters in individuals with acute abdomen as well as developed intra-abdominal hypertension becomes imperative. Such alterations in vital physiological functions serve as early indicators of organ malfunction, emphasizing the importance of immediate medical attention [2, 10, 13]. The current study aims to comprehensively investigate and understand these dynamic interactions in patients experiencing acute abdominal conditions.

The aim of this clinical study is to investigate intra-abdominal pressure in patients presenting with acute abdominal conditions, categorizing them based on intra-abdominal hypertension (IAH) and comparing outcomes such as mortality rates.

Materials and Methods

Study design

A prospective cross-sectional study

Study setting

The study was conducted in the Department of General Surgery of the Indira Gandhi Institute of Medical Sciences (IGIMS) in Patna, Bihar, India, spanning from January 2022 to December 2023.

Participants

The study involved 150 individuals after implying all the selection criteria.

Inclusion criteria

- Participants eligible for inclusion were individuals diagnosed with acute abdomen

Exclusion criteria

- Enrolled in a long-term renal support program,
- Individuals with a Foley catheter
- Those who underwent operation prior to hospitalization in the Intensive Care Unit.
- Patients with lower urinary tract injury in case of blunt trauma abdomen
- Patients with bladder dysfunction
- Patients with head injury and spinal injury in case of blunt trauma abdomen

Intervention

The cohort was then divided into two categories based on IAP values: those with normal abdominal pressure (60 individuals) and those with intra-abdominal hypertension (90 individuals). According to the WSACS definition (Table 1), IAH was identified by a consistent presence or recurring increase in abdominal pressure greater than or equal to 12 mm of Hg. The IAH group was subsequently subdivided into four categories based on mean IAP values, ranging from 12 to 15 mmHg (first group) to >25 mmHg (fourth group). Furthermore, the study scrutinized variations in examined variables between survivors and non-survivors within the IAH groups, offering a comprehensive assessment of the effect of intra-abdominal hypertension on medical outcomes.

Tabe 1: Grading schemes for elevated intra-abdominal pressure

Grade	WSACS definition (mmHg)
I	12-15
II	16-20
III	20-25
IV	>25

Study size

The study included 360 patients from which 150 were included in the study who met specific inclusion criteria.

Sample size determination

Patients who enrolled after filling the inclusion criteria. For calculating sample size the following formula was used:

$$N\Delta = \frac{2(Za+Z1\text{-}\beta)2\sigma^2}{2}$$

Where, N= sample size, Z is a constant

Za is set by convention according to accepted a error of 5% as 1.649 Z1-β is set by convention according to accepted 1-β or power of study of 80% as 0.8416Σ is standard deviation estimated Δ is difference in the effect between two interventions (estimated effect size).

Data collection

The criteria for diagnosing acute abdominal conditions particularly acute abdomen were based on an updated definition, necessitating the presence of a minimum of two among three criteria: characteristic epigastric discomfort, a 3-fold rise in serum lipase or amylase levels, as well as confirmation through computed tomography examination for cases with ambiguous presentation.

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Each patient was equipped with a Foley catheter, with one side positioned in the urinary bladder and the other connected to both the collection pouch and the infusion set hose equipped with a ruler. During measurements, the collection pouch was detached and linked to the other section of the infusion set hose, to assist in injecting the empty bladder with 25 mL saline. The readings were taken when the patients lied horizontally, and at the end of the expiratory flow, around 30 to 60 seconds after injecting the saline. The baseline for measurements was set at the intersection of the lateral midclavicular line and the hip crest. Measurement sessions were repeated in 12-hour interval until the patients were discharged from the Intensive Care Unit.

Comparisons were conducted to assess the mean Intra-Abdominal Pressure (IAP) values across all cohorts. Average values of various examined variables, including age, body mass index (BMI), treatment duration, Sequential Organ Failure Assessment (SOFA) score, heart rate, lactate levels, abdominal perfusion pressure, and hourly diuresis, among others were used for the comparisons.

Bias

The study's single-center design at IGIMS, Patna introduces the possibility of selection bias, limiting the generalizability of findings. Additionally, the observational nature of the study raises concerns about potential confounding variables that could influence causal inferences.

Statistical Analysis

Data analysis employed IBM SPSS Statistics and Statistica. Descriptive statistics included mean, standard deviation, and range. Correlations, group differences, and regression analysis were assessed with significance levels of $p < 0.05$ and $p < 0.01$.

Ethical considerations

The IGIMS ethics committee approved the study protocol, and informed consent was obtained from patients or their legal surrogates. The study adhered to established ethical standards.

Results/Outcomes

Participants

The study initially involved 360 patients, each of whom underwent evaluation for inclusion based on specific criteria. Out of these, 30 patients were excluded as they were enrolled in a long-term renal support program. Additionally, 45 patients with a Foley catheter were excluded, along with 25 patients who had undergone an operation before admission to the Intensive Care Unit. Furthermore, 20 patients with lower urinary tract injuries in the case of blunt trauma abdomen, 15 patients with bladder dysfunction, and 10 patients with head or spinal injuries in the context of blunt trauma abdomen were excluded from the study. After applying these exclusion criteria, a total of 150 patients who met the inclusion criteria for acute abdomen were included in the research.

The study comprised 150 individuals diagnosed with acute abdomen, with 60 exhibiting normal IAP values and 90 experiencing IAH. Within the IAH group, patients were categorized into four subgroups based on their IAP levels, with mean values of 13.1 mmHg, 17.3 mmHg, 22.2 mmHg, and 25.6 mmHg in the respective groups. Correspondingly, the first, second, third, and fourth groups comprised 23, 15, 5, and 3 patients, respectively (Table 2). Notably, the mortality rate among acute abdomen patients was 33 %, with 22.5% in those belonging to normal cohort (18 deaths out of 80) and 40% in the high IAP group (48 deaths out of 120). The comparison of IAP levels and treatment outcomes revealed statistical variations ($p = 0.012$). Further analysis within the IAH group, comparing survived and dead patients is shown in table 3.

Table 2: Characteristics of patients with acute abdomen

Group	Number of Patients	Mean IAP (mmHg)
Normal IAP	60	-
IAH Group 1	23	13.1
IAH Group 2	15	17.3
IAH Group 3	5	22.2
IAH Group 4	3	25.6

Table 3: Attributes of patients with IAH

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Characteristics	**Patients with normal IAP (n = 60)**	**Patients with intra-abdominal hypertension (n = 90)**		***p*-value**
		Surviving patients (n = 54)	**Deceased patients (n = 36)**	
IAP (mm of Hg)	7.4	12.1	23.6	0.001
Mean Age (yrs)	61.4	62.5	64.9	0.05
Number of treatment days	5.2	5.1	8.2	0.09
Body mass index	17.9	18.5	20.1	0.001
APACHE II score	21.6	21.3	26.2	0.05
SOFA score	6.6	5.7	8.01	0.05
CVP (cm H2O)	9.1	8.2	12.1	0.002
MAP (mm of Hg)	86.1	89.1	72.7	0.001
Lactate (mmol per L)	1.5	1.3	2.8	0.001
APP (mm of Hg)	78.4	79.2	50.4	0.001
FG (mm of Hg)	71.4	67.4	31.6	0.001
Diuresis (mL per hour)	87.3	67.2	38.1	0.001

In the IAH patient groups, the average IAP values were contrasted with various clinical parameters (BMI, MAP, APACHE II score on admission, APP, diuresis per hour, FG rate, lactate levels, and treatment days) using ANOVA and post hoc Tukey tests, revealing statistical significance.

Scrutiny of Pearson rank correlation coefficients unveiled noteworthy relationships. Notably, there were strong positive correlations between MAP and FG, MAP and APP, and an extremely strong positive correlation between APP and FG. Other correlations included weak negative correlations of MAP with lactate, CVP, and SOFA. Strong correlations were observed between APP and FG, FG and SOFA, and CVP and SOFA.

The trends in CVP variables and SOFA score illustrate a gradual rise in SOFA score and CVP values with rising IAP levels, with the fourth group exhibiting the highest CVP values (>22 cm H_2O).

Discussion

The study revealed a significant statistical difference between two patient groups-normal and elevated IAP-across all tested parameters except treatment duration and age. The overall fatality was 33%, with a substantial variation between normal and elevated IAP groups, indicating a higher fatfality incidence in the IAH cohort. Significance was observed in age, APACHE II score (21.3-26.2), SOFA score (5.7-8.01), BMI (18.5-20.1), MAP (72.7-89.1), FG (31.6-67.4), APP (50.4-79.2), diuresis (38.1-67.2), and CVP (8.2-12.1), emphasizing the impact of these variables on survival of the IAH cohort. Deceased patients in this cohort were characterized by older age and elevated values of most of these variables excluding MAP, FG, APP, and hourly diuresis, which showed reduced values. Notably, the number of treatment days showed no significant variation amongst the 2 cohorts.

The mortality rate among acute abdomen patients with intra-abdominal hypertension is notably high at around 40%, primarily attributed to organ damage, necrotic pancreatitis, and bacterial infections [5, 6]. Timely care is crucial to prevent adverse effects, as fatality rises with the incidence of systemic or local side effects. IAH development, often concurrent with acute abdomen, may cause early organ damage and abdominal compartment syndrome (ACS), particularly in septic shock, perfusion disorders, and multi-organ malfunctioning due to increased IAP [19-21].

The prognostic evaluation of acute abdomen commonly involves the APACHE II and SOFA scoring systems, linking higher IAP levels to heightened organ damage and prolonged ICU stays [22, 23]. Deceased patients displayed elevated maximal IAP, SOFA, lactate levels, age, creatinine, alkali insufficiency, and APACHE II score, with the highest fatality incidence in individuals with increased IAP values, indicating a positive association between maximal APACHE II and SOFA scores and IAP rise [22]. Recent findings suggest

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predictive potential, with an APACHE II score ≥12 and a SOFA score ≥6 indicating IAH risk [24].

Linear regression analysis demonstrated associations between maximal IAP and traditional prognostic factors, emphasizing the intensity of acute abdomen [13]. In the present investigation, average IAP values were contrasted with daily examined variables within IAH groups. Statistically significant differences were observed in BMI across groups, with higher BMI correlating with increased IAP due to greater abdominal muscle contraction effort [25, 26]. The study contrasts prior findings, as the APACHE II score showed no significant difference or correlation with IAP, contradicting its impact on disease outcomes in previous studies [27, 28].

Contrastingly, the SOFA score displayed significant differences and a strong positive relationship with IAP across groups, indicating a consistent correlation between IAP increase and higher SOFA scores. The analysis revealed a monotonic increase in central venous pressure (CVP) with elevated IAP, particularly significant in the group with the highest IAP values. Mean arterial pressure (MAP) showed significant differences and an extremely strong negative correlation with IAP, reflecting physiological changes leading to reduced blood flow and lowered MAP.

Abdominal perfusion pressure (APP) and filtration gradient (FG) exhibited significant differences and negative correlations with IAP, particularly notable between the first and third groups. Diuresis per hour decreased significantly with rising IAP, reflecting impaired kidney perfusion in IAH patients. Lactate values showed very significant differences between groups, positively correlating with IAP, highlighting inadequate organ perfusion and toxic substance accumulation in IAH patients. The study contributes valuable insights into the complex interplay between IAP and various clinical parameters, shedding light on the impact of IAH on organ perfusion and overall patient outcomes.

Robust correlations between MAP, APP, and FG were observed, while patients with deteriorating conditions showed opposing changes in SOFA, MAP, and APP. The inadequate response to therapy and resulting perfusion disorders, driven by increased IAP, influenced SOFA score shifts. This comprehensive perfusion disorder extended to kidney function, manifested through alterations in APP, FG, and hourly diuresis, underlining the necessity for quicker identification of SOFA score variations in IAH patients with acute abdomen.

Conclusion

In conclusion, this study sheds light on the critical implications of intra-abdominal hypertension (IAH) in patients with acute abdomen, showcasing its substantial impact on mortality rates and emphasizing the need for prompt intervention to mitigate complications. The assessment of scoring systems like APACHE II and SOFA proves valuable in predicting IAH development, with maximal intra-abdominal pressure (IAP) serving as a key indicator of acute abdomen severity. The study unravels the intricate associations between IAP and clinical parameters, revealing BMI as a significant factor influencing IAP levels. Physiological changes, including shifts in MAP, abdominal perfusion pressure (APP), filtration gradient (FG), diuresis, and lactate levels, provide comprehensive insights into organ perfusion disturbances associated with IAH. This research contributes to a deeper understanding of the dynamic relationship between IAP and clinical outcomes, advocating for vigilant monitoring and early intervention strategies in the management of acute abdomen to improve patient prognoses.

Limitations

The limitations of the study include a single-center design, which may constrain the generalizability of findings. The observational nature of the study introduces the possibility of confounding variables influencing causal inferences. Additionally, variations in treatment strategies were not extensively addressed, potentially impacting the interpretation of outcomes.

Recommendations

The study recommends further investigation into standardized treatment protocols for acute abdomen and intra-abdominal hypertension, emphasizing the need for multi-center trials to enhance generalizability and inform evidence-based interventions.

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List of Abbreviations

IAP - Intra-Abdominal Pressure
IAH - Intra-Abdominal Hypertension
ACS - Abdominal Compartment Syndrome
ICU - Intensive Care Unit
WSACS - World Society Of The Abdominal Compartment Syndrome
BMI - Body Mass Index
APACHE - Acute Physiology, Age, And Chronic Health Evaluation
SOFA - Sequential Organ Failure Assessment
CVP - Central Venous Pressure
MAP - Mean Arterial Pressure
APP - Abdominal Perfusion Pressure

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Conflict of interest

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