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The Relationship between Intra-Abdominal Pressure and Abdominal Perfusion Pressure Measurements with Prognosis in Patients Monitored in Critical Emergency Care

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Abstract

Aim: Intra abdominal hypertension (IAH) and abdominal compartment syndrome have emerged as significant causes of morbidity and mortality in critically ill surgical and medical patients. The prognostic value of elevated intra-abdominal pressure (IAP) has led to its recognition as a near-routine vital parameter in high-risk patients. This study aimed to monitor IAP elevations, low abdominal perfusion pressure (APP), and their clinical implications in patients admitted to emergency critical care units.

Materials and Methods: This study included 89 patients admitted to intensive care units (ICUs), whose IAP was measured using the bladder pressure method. A volume of 25 mL saline was instilled into the bladder, and measurements were taken with the symphysis pubis level as the zero-reference point. Patients were grouped based on IAP values (<12 mmHg and ≥12 mmHg) and APP values (<60 mmHg and ≥60 mmHg). Morbidity outcomes included inotropic support, ventilator dependency, sepsis incidence, SOFA scores, and mortality rates. Statistical analyses were performed.

Results: Among 89 patients, 36 had IAH, and 34 exhibited low APP. Patients with IAH and low APP demonstrated a higher need for inotropic support, increased sepsis incidence, and higher rates of organ failure. A strong association was observed between mortality and low APP, particularly in cases of IAH.

Conclusion: Bladder pressure measurement is a simple and effective method to evaluate IAP in critically ill ICU patients. Elevated IAP and low APP were associated with poorer morbidity and mortality outcomes. IAP measurement should be considered essential for the survival prediction of critically ill patients in future ICU protocols.

Keywords: Intra-abdominal pressure, intra-abdominal hypertension, intensive care unit, critically ill patients, abdominal perfusion pressure

Introduction

The presence of intra-abdominal hypertension (IAH), which results from increased intra-abdominal pressure (IAP) and can progress to abdominal compartment syndrome (ACS), has recently been recognized as a significant cause of morbidity and mortality in critically ill surgical and medical patients (1,2). Elevated IAP leads to pressure-induced organ dysfunction, causing significant impairments in cardiac, pulmonary, renal, gastrointestinal, hepatic, and central nervous system functions. Studies have shown that IAH disrupts venous return to the right side of the heart from the periphery, thereby reducing cardiac output. This reduction results in lower blood pressure, which impairs organ perfusion pressure. The pathophysiological process initiated by regional blood flow disturbances worsens with the development of ACS, ultimately leading to end-organ failure (3,4).

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Therefore, in critically ill patients, such as those in intensive care units (ICUs), IAH and elevated IAP have been identified as independent predictors of multi-organ failure and mortality (5-10). The prognostic significance of IAP necessitates routine measurement of this physiological parameter in at-risk patients. Early measurement of IAP facilitates identification of IAH, enabling comprehensive medical management strategies to reduce elevated IAP, restore end-organ perfusion, and implement timely decompression and physiologically appropriate fascial closures for cases of refractory organ dysfunction. These strategies have been shown to significantly improve patient survival, reduce complications, and optimize resource utilization (11).

Abdominal perfusion pressure (APP), defined as the difference between mean arterial pressure (MAP) and IAP, not only reflects the severity of IAP but also provides insight into its impact on abdominal blood flow. APP has been demonstrated in several studies to be superior to IAP alone in guiding resuscitation targets (12-14).

This study aims to evaluate the clinical implications of routine IAP and APP measurements in patients admitted to the ICU for more than 24 hours, alongside their monitoring practices.

Materials and Methods

This prospective observational study was conducted in the Emergency Medicine Department of Selçuk University Meram Faculty of Medicine Hospital between October 2008 and June 2009, following approval from the local ethics committee (decision number: 2008/209, date: 25.07.2008). Written informed consent was obtained from the patients.

Study Protocol

The study included medical and surgical patients who required intensive care and were monitored in the emergency department with an indwelling urinary catheter for more than 24 hours. Demographic and clinical data such as age, sex, vital signs, mechanical ventilation status, presence of sepsis, use of positive inotropic support, daily SOFA scores, IAP, APP, length of ICU stay, and survival outcomes were recorded on a structured data form. Patients under 18 years of age, pregnant patients, and those with nephrotomies or prior bladder surgeries were excluded from the study.

IAP was measured using the bladder pressure method, which is both practical and widely accepted. A central venous pressure manometer was connected to the tip of the urinary catheter, and 25 mL of sterile saline was instilled into the empty bladder. Measurements were taken in the supine position at the end of expiration, with the symphysis pubis set as the "0" reference point. The pressure readings were recorded in cmH^2O and subsequently converted to mmHg.

IAP measurements commenced within the first hour of admission to the ICU and were repeated every 12 hours until discharge, transfer to another department, or death. For patients with prolonged ICU stays, IAP monitoring was limited to a maximum of seven days. The highest IAP value recorded each day was used for analysis. Patients were categorized into groups based on their IAP (<12 mmHg and ≥12 mmHg) and APP (<60 mmHg and ≥60 mmHg). Simultaneously, MAP was recorded, and APP was calculated using the formula:

APP = MAP - IAP

Statistical Analysis

Data were analyzed using SPSS version 13.0 software. Categorical variables were expressed as n (%), while numerical variables were presented as mean ± standard deviation. Comparisons between groups (IAP <12 mmHg vs. IAP ≥12 mmHg; APP <60 mmHg vs. APP ≥60 mmHg) were performed using the chi-square test for categorical variables, the Mann-Whitney U test for non-normally distributed numerical variables; and the Independent samples t-test for normally distributed numerical variables. A p value of <0.05 was considered statistically significant.

Results

During the study period, 174 patients were admitted to our emergency ICU. Of these, 85 patients were excluded for the following reasons: 48 (56.5%) were discharged or transferred to other departments within 24 hours, 14 (16.5%) were under 18 years of age, 7 (8.2%) were pregnant, 13 (15.3%) did not require a urinary catheter, and 3 (3.5%) had nephrostomy tubes. A total of 89 patients were included in the study, and IAP measurements were completed (Figure 1). The demographic and clinical characteristics of these patients at the time of ICU admission are summarized in Table 1.

The mean age of the patients was 65.7±15.7 years, and 47 patients were male. Upon ICU admission, the SOFA score was 6.83±3.19, the MAP was 79.6±19.7 mmHg, the mean IAP was 9.9±5.7 mmHg, and the APP was 69.5±21.8 mmHg.

Table 1. Demographic and clinical characteristics of patients in intensive care follow-up			
Socio- demographic and general characteristics			**Mean ± SD**
	Age		65.7±15.7
	GKS		11.4±4.6
	SOFA		6.8±3.2
	Gender	Male	47 (52.8)
		Female	42 (47.2)
			n (%)
	Ventilator support		49 (55.1)
	Sepsis status		24 (27.3)
	Patient fate	Ex	34 (41.0)
		Under observation	18 (21.7)
		Transfer to another clinic	31 (37.3)
Clinical evaluations	MAP		79.6±19.7
	IAP-1		9.9±6.1
	IAP-2		9.9±5.7
	APP		69.45±21.8
	Pulse rate		99.12±20.1
	Respiratory rate		23.04±6.3
Pharmaceutical applications			**n (%)**
	Mannitol		18 (20.5)
	Diuretic		23 (26.4)
	Inotrope support		31 (34.8)
Laboratory tests			**Mean ± SD**
	Ph		7.36±0.21
	pO_2 (mmHg)		83.40±36.55
	pCO_2 (mmHg)		36.81±11.68
	SpO_2		89.34±10.48
	HCO_3 (mmol/L)		21.59±7.41
	Urea (mg/dL)		81.47±51.37
	Creatinine (mg/dL)		1.79±1.17
	Hgb (g/dL)		11.06±2.62
	PLT (10^3/µL)		227.91±123.91
			Median (min-max)
	Bilirubin (mg/dL)		1 (0.1-13.5)
	CRP (mg/L)		68 (0-128)

GKS: Glasgow coma scala, SOFA: Sequential organ failure assessment, MAP: Mean arterial pressure, IAP: Intra abdominal pressure, APP: Abdominal perfusion pressure, CRP: C-reactive protein, Hgb: Hemoglobin, PLT: Platelet

At the time of ICU admission, elevated IAP was observed in 22 (25%) of the 89 patients. During follow-up, an additional 14 patients (16%) developed elevated IAP. Of the total 89 patients, 30 (34%) required positive inotropic support, and 49 (53%) required mechanical ventilation. ACS developed in 5 patients (5.6%), 3 of whom died.

Patients were categorized into two groups based on their IAP values: those with IAP ≥12 mmHg and those with IAP <12 mmHg. Comparisons of variables between these groups are presented in Table 2. Additionally, patients were grouped according to APP values (<60 mmHg and ≥60 mmHg), and the results are shown in Table 3.

Among the 36 patients with elevated IAP, 18 (50%) died, whereas 16 (29%) of the 53 patients with normal IAP died (p=0.059, Table 2). When all 89 patients were evaluated based on APP, 34 patients

(38.2%) had APP values below 60 mmHg. Of these 34 patients, 18 (52.9%) died, compared to 16 (29%) deaths among the 55 patients with APP ≥60 mmHg (p=0.02, Table 3).

When IAP and APP were evaluated together, 11 (31%) of the 36 patients with elevated IAP had APP values ≥60 mmHg. Of these 11 patients, 10 (91%) were discharged or transferred to other departments, and only 1 (9%) died. In contrast, among the 25 patients (69%) with elevated IAP and APP <60 mmHg, 15 (60%) died, and 10 (40%) were discharged or transferred (Table 4).

Among the 53 patients with normal IAP and the 44 patients with normal APP (above 60 mmHg), 15 (34%) patients died. In contrast, among the 9 patients with normal IAP but APP below 60 mmHg, 3 (33%) died, while 6 were either discharged or transferred to other clinics (Table 4). Additionally, all 5 patients with low APP (below 60 mmHg for three consecutive days) among the 34 patients with low APP died.

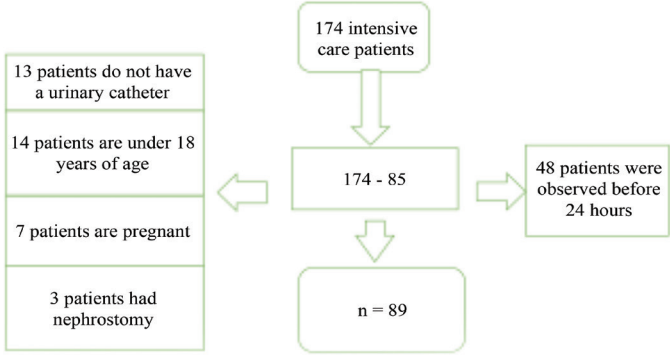

Figure 1. Patient selection scheme for the study

Table 2. Comparison of parameters in patient groups according to IAP ≥12 mmHg (n=36) and IAP <12mmHg (n=53)

	IAP ≥12 mmHg	IAP <12mmHg	p value
	Mean ± SD	Mean ± SD	
Age	69.9±14.6	62.7±15.8	0.032
SOFA, First day	8.06±3.34	6.00±2.84	0.002
MAP, First day	71.9±20.4	84.8±17.6	0.002
	n (%)	n (%)	
APP <60 mmHg	25 (69.4)	9 (17.0)	<0.001
Sepsis	12 (33.3)	11 (21.6)	0.220
Positive inotrope	19 (52.8)	10 (19.6)	0.001
Mechanical ventilation	21 (58.3)	28 (52.8)	0.608
Mortality	18 (50)	16 (30.1)	0.059

SOFA: Sequential organ failure assessment, MAP: Mean arterial pressure, APP: Abdominal perfusion pressure, IAP: Intra abdominal pressure

Discussion

This study demonstrates that elevated IAP and decreased APP are critical parameters for patients admitted to the ICU. The mortality and morbidity of these patients are directly related to these parameters. In patients with IAH and low APP, morbidity was found to be higher, as indicated by the increased need for positive inotropic support, sepsis, and organ failure. Therefore, these patients required more supportive treatment. The measurement of vital parameters, like other important health indicators, is crucial for ICU patients and should be a part of routine monitoring.

In our study group, the incidence of IAH was found to be 40.4% (36/89). While IAH was present in 22 patients at the time of initial ICU admission, 14 developed IAH during follow-up. The data at admission were similar to those of Malbrain et al. (14) prospective multicenter epidemiological study. In that study, the one-day incidence of IAH was found to be 59%. The difference in this rate could be attributed to differences in IAH values. Both in the Malbrain et al. (14), a value greater than 12 mmHg was

Table 3. Comparison of parameters in patient groups according to APP <60mmHg (n=34) and APP ≥60mmHg (n=55)

	APP <60mmHg	APP ≥60mmHg	p value
	Mean ± SD	Mean ± SD	
Age	67.5±15.1	64.5±16.1	0.385
SOFA, first day	8.21±3.29	5.98±2.85	0.001
MAP, first day	62.8±12.9	90.0±15.6	<0.001
	n (%)	n (%)	
IAP ≥12 mmHg	25 (73.5)	11 (20.0)	<0.001
Sepsis	12 (35.3)	11 (20.0)	0.101
Positive inotrope	21 (61.8)	8 (14.5)	<0.001
Mechanical ventilation	23 (67.6)	26 (47.3)	0.048
Mortality	18 (52.9)	16 (29)	0.02

SOFA: Sequential organ failure assessment, MAP: Mean arterial pressure, IAP: Intra abdominal pressure, APP: Abdominal perfusion pressure

Table 4. Mortality or survival status of patients in the IAP and APP groups

		IAP high n (%)	IAP normal n (%)
APP Low	Ex	15 (60)	3 (33.3)
	Survival	10 (40)	6 (66.7)
	Total	25 (100)	9 (100)
APP Normal	Ex	1 (9.1)	15 (34.1)
	Survival	10 (81.9)	29 (65.9)
	Total	11 (100)	44 (100)

IAP: Intra abdominal pressure, APP: Abdominal perfusion pressure

considered IAH for a single measurement. Some studies use average IAP values, whereas most studies use the highest IAP values (15). Some studies use average IAP values, whereas most studies use the highest IAP values. The debate over which value, the average or highest IAP measurement, best reflects the clinical condition, remains. In our study, we used the highest value, which is more widely accepted.

Another critical variable is the APP, which is physiologically advantageous as it indicates the severity of IAH and inadequate organ perfusion. A threshold of 60 mmHg is typically used for APP (16). In our study, 25 out of 36 patients (69%) with elevated IAP had an APP below the critical threshold of 60 mmHg. Among these 25 patients, 15 (60%) died. Additionally, all five patients with APP below 60 mmHg for three consecutive days died. Our results suggest a significant relationship between increased IAP, low APP, and mortality.

Other research indicates that many physicians perform IAP measurements when clinically indicated, with only 27% of them conducting measurements every 4 to 8 hours (17). In our study, measurements were taken every 12 hours for ICU patients. Among the 89 patients, 36 exhibited IAH. Mortality in patients with IAH was 45%, while it was 34% in patients without IAH. These results support the impact of IAH on mortality. Early intervention upon detecting IAH by ICU physicians is vital for improving patient outcomes.

In observational studies, a tight relationship between negative fluid balance and survival has been reported (18, 19). Some studies suggest that early and goal-directed therapy with aggressive fluid resuscitation yields better outcomes in severe sepsis and septic shock (20). In our study, 30 patients received positive inotropic support due to shock. Contrary to the literature, our findings indicated that despite the administration of supportive therapy in cases of elevated IAP, particularly with low APP, there was poor clinical progression and high mortality rates.

The SOFA scores were calculated for the patients under follow-up. In patients monitored after the third day, no significant relationship was found between SOFA scores and outcomes. However, in patients monitored during the first two days, a significant relationship was found between SOFA scores and morbidity, as well as mortality. This may be due to the higher number of patients and the increased mortality rates in the first two days.

There is strong evidence supporting the inclusion of IAP measurement in the classification of vital signs for monitoring. A multicenter study further clarifies the effects of IAP and APP, including comorbid factors (15). In our study, the difference in outcomes between patients who survived and those who died based on IAP and APP measurements was evident. In patients with IAH, mortality was 50%; for those with low APP (below 60 mmHg), it was 53%. These values were higher than the overall ICU mortality rate of 38%.

The literature suggests that APP is numerically superior to other parameters in predicting survival in patients with IAH and ACS. Failure to maintain at least 60 mmHg of APP during the day has been shown to help predict survival in IAH and ACS (21-23).

Study Limitations

There are several limitations in this study. Some measurements may have been influenced by the inability to position the patient, which could have contributed to increased IAP due to head elevation. Continuous IAP monitoring was not feasible, and thus the duration of IAH could not be precisely determined. Furthermore, the relatively small sample size and the single-center design limit the generalizability of the results to all ICU settings.

Conclusion

Our study has shown that nearly half of the patients in the ICU experience increased IAP, and this pressure elevation appears to be a significant predictor of adverse outcomes such as mortality, sepsis, and the need for positive inotropic support. We believe that the identification of increased IAP and decreased APP can be crucial for early intervention. Therefore, it may be beneficial to monitor IAP and APP at regular intervals in intensive care patients to allow for timely preventive measures.

Ethics

Ethics Committee Approval: This prospective observational study was conducted in the Emergency Medicine Department of Selçuk University Meram Faculty of Medicine Hospital between October 2008 and June 2009, following approval from the local ethics committee (decision number: 2008/209, date: 25.07.2008).

Informed Consent: Written informed consent was obtained from the patients.

Footnotes

Author Contributions

Surgical and Medical Practices: O.L.D., E.D., Z.D.D., Concept: O.L.D., A.S.G., B.C., Design: O.L.D., A.S.G., B.C., Data Collection or Processing: O.L.D., E.D., Z.D.D., Analysis or Interpretation: O.L.D., Literature Search: O.L.D., Writing: O.L.D., A.S.G.

Conflict of Interest: The authors declare that they have no conflict of interest.

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