Incidence and Prognostic Factors for Mortality of Abdominal Hypertension in Critically Ill Surgical Patients in THAI-SICU Study

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Objective: *This study aimed to investigate the incidence and prognostic factors of mortality in intra-abdominal hypertension that developed during admission in the surgical intensive care units in Thailand.*
Material and Method: *This was a prospective observational study in nine university-based surgical intensive care units in Thailand. (THAI-SICU) The suspected patients who had the intra-abdominal pressure more than 12 mmHg were defined as intra-abdominal hypertension (IAH). The patients were followed until discharge.*
Results: *Among 4,652 cases, a total of 71 cases (1.5%) developed IAH. The average age was 53.05±20.26 years. The median APACHE II score was 13 (9-15). Eighteen patients received surgical decompression as treatment. Metabolic acidosis (pH <7.2) and abdominal aortic surgery were the significant factors for mortality in intra-abdominal hypertension patients.*
Conclusion: *The incidence of intra-abdominal hypertension in the critical surgical care units was low in this cohort. Intra-abdominal hypertension in patients who previously received abdominal aortic surgery and who had concomitant acidosis was the independent risk factor of mortality.*

Keywords: *Intra-abdominal hypertension, Critical care, Mortality, Compartment syndrome*

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Compartment syndrome occurs after an increase in intra-compartment pressure which can occur in any anatomical compartment of the body including the abdomen. The increased pressure impairs cellular function and the tissue that is contained in that compartment[1].

Intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS) are associated with multi-organ dysfunction, morbidity and mortality in critically ill patients[2-5]. The World Society on Abdominal Compartment Syndrome has identified the definition of IAH as a sustained or repeated pathological elevation in intra-abdominal pressure ≥12 mmHg and ACS as a sustained or repeated pathological elevation in intra-abdominal pressure (IAP) >20 mmHg with newly detected organ dysfunction[6].

The aims of this study were: 1) reporting the prevalence of IAH and ACS in critically ill surgical patients, and 2) identify risk factors for mortality in the patients who had IAH.

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Material and Method

Data collection

This was part of a multi-center Thai university-based surgical intensive care unit (THAI-SICU study) which was a prospective-multicenter observational study in nine university-based surgical intensive care units. The study collected demographic data and complications from the time of admission until the patients were discharged or after 28 days from admission. Details of the enrollment were as described in a previous publication[7]. IAH was observed clinically by a daily checklist form. When the patients in the cohort were suspected to develop IAH, it was confirmed by IAP measurement. Only patients who had IAP ≥12 mmHg were further sub-enrolled into the IAH group

and intra-abdominal pressure and treatment were prospectively recorded until the events subsided. The risk factors for IAH were also collected. The factors included acute respiratory failure with high positive end-expiratory pressure (PEEP) level, post abdominal surgery, multiple trauma, burn, obesity, ileus, bowel obstruction, cirrhosis with marked ascites, acidosis, hypothermia, coagulopathy, massive blood transfusion, severe sepsis or septic shock, massive IV fluid intake, severe acute pancreatitis, damage control surgery, bowel gangrene, and abdominal aortic surgery. The ethics committee or Institutional Review Board approved the study before data collection was performed.

Intra-abdominal pressure measurement

Measurements were done in patients suspected to have IAH following the method recommended by the World Society of the Abdominal Compartment Syndrome (WSACS)[6]. Briefly, the measurement was done when patients were in a supine position and at end-expiration phase. The measurement was via the bladder after an infusion of 25 mL of sterile saline.

Once the IAH was documented, the measurement was repeated after the treatment and the highest pressure was recorded on a daily basis.

Definition

IAH is classified into 4 grades according to the IAP. Grade 1 is an IAP between 12 and 15 mmHg, grade 2 is an IAP between 16 and 20 mmHg, grade 3 is an IAP between 21 and 25 mmHg and grade 4 is an IAP greater than 25 mmHg.

ACS is classified into three different types according to the etiology: primary, secondary, or tertiary ACS. Primary ACS is an ACS that has a primary intra-abdominal pathology. Secondary ACS occurs as a result of extra-abdominal causes such as massive bowel edema after resuscitation. Tertiary ACS is an ACS that recurs after the resolution of the first episode of the compartment syndrome[8].

Data analysis

Descriptive data were reported in percentage and standard deviation (SD) and interquartile range (IQR). Student's t-test or Rank sum test was used for continuous data. Chi-square or Fisher's exact test was used for categorical data. The risk factors for death were described in odds ratio. Univariate analysis between factors and mortality was done and all *p*-values <0.2 were selected for multiple logistic regression with backward elimination. Statistically significant differences were defined as $p<0.05$.

Results

The data were collected from 18 April 2011 to 30 January 2013. From the total number of cases was 4,652 cases, 71 cases were reported to have IAH. Four cases had IAP less than 12 mmHg but those patients were included into the study since they received treatment as IAH. Three centers did not report any cases. The incidence accounted for 1.5% of ICU admissions. The average age was 53.05$\pm$20.26 years. The median APACHE II score was 13 (9-15). The majority of the patients were admitted in the SICUs because of intra-abdominal problems (35.2%) followed by trauma (33.8%). Seventy-three percent were male. Fifty-three cases were diagnosed as primary IAH. Two cases were secondary IAH and none of the cases had tertiary IAH. The median number of days from admission to IAH development was 2 days (1-3.5). The mean maximum IAP was 18 (5.25). Six patients had an IAP >25 mmHg. There were no different in mortality rate in each grade of IAH. The characteristics of the patients are described in Table 1. Eighteen patients received surgical decompression as treatment. Ten of 18 patients had surgical decompression as their first therapeutic modality while others had surgical decompression after failed medical treatment.

The IAH patients in the non-survival group had a higher median APACHE II score on admission (12 vs. 19, $p = 0.005$) and a higher average IAP (17.4 vs. 19.8, $p = 0.129$). The non-survival group had a higher number of patients who had acidosis (2.1% vs. 40%, $p<0.001$), coagulopathy (17% vs. 33.3%, $p = 0.272$), blood transfusion >10 U/day (23.4% vs. 40%, $p = 0.318$), and abdominal aortic surgery (14.9% vs. 46.7%, $p = 0.028$). The risk factors are reported in Table 2.

Multivariable analysis showed metabolic acidosis and abdominal aortic surgery significantly increased the odds of mortality in the patients who had intra-abdominal hypertension. The odds ratios were 22.87 and 6.28, respectively (Table 3).

Discussion

The incidence of IAH in critically ill patients varies and depends on the policy for screening and the cut point to diagnose IAH. The incidence in our study, which was reported as 1.5% of ICU admissions was quite low when compared with a study from Vidal et al that performed serial measured intra-abdominal pressure

Table 1. Characteristics of the patients who had abdominal hypertension

Characteristics	All n = 71	Survived n = 54	Dead n = 17	*p*-value
Gender				
Male: female	73:27	70:30	82:18	0.531
Average age, year, (SD)	53.03 (20.26)	50.2 (20.8)	62.2 (15.7)	0.032
APACHE II score (IQR)	13 (9-15)	12 (7-16)	19 (14-21)	0.005
Body mass index (kg/m^2, (IQR))	24.7 (5.8)	23.7 (21.5-27.5)	24.1 (21.3-27.7)	0.767
Admission category (%)				0.196
Abdomen (GI-HBP)	25 (35.2)	19 (35.2)	6 (35.3)	
Trauma	24 (33.8)	21 (38.9)	3 (17.6)	
Cardiovascular	13 (18.3)	6 (11.1)	7 (42.2)	
Sepsis	4 (5.6)	3 (5.6)	1 (5.9)	
Respiratory	2 (2.8)	2 (3.1)	0 (0)	
Metabolic problem	1 (1.4)	1 (1.9)	0 (0)	
Renal-GU	1 (1.4)	1 (1.9)	0 (0)	
Site of abdominal operation (%)				
Upper abdomen	32 (45)	24 (44.4)	8 (47.1)	1
Lower abdomen	29 (40.8)	20 (37)	9 (52.9)	0.379
Type of Surgery				0.542
Emergency surgery	33 (46.5)	23 (42.6)	10 (58.8)	
Elective surgery	8 (11.3)	7 (13.0)	1 (5.8)	
Unidentified type	2 (2.8)	2 (3.7)	0 (0)	
No surgery	28 (39.4)	22 (40.7)	6 (35.2)	
Fluid balanced before IAH, L (IQR)	2.9 (1.4-7.2)	2.9 (1.0-6.3)	4.6 (2.0-.5.9)	0.244
Maximum IAH, (SD)	18 (5.25)	17.4 (4.7)	19.8 (6.5)	0.129
IAH grading				
I	20 (33.8)	20 (45.5)	4 (26.7)	0.318
II	24 (28.2)	15 (34.1)	5 (33.3)	
III	9 (12.7)	6 (13.6)	3 (20)	
IV	6 (8.5)	3 (6.8)	3 (20)	
Type of intra-abdominal hypertension				
Primary	53 (96.4)	39 (95.1)	14 (100)	1.000
Secondary	2 (3.6)	2 (4.9)	0 (0)	

Value with SD is mean and value with IQR is median.
SD = standard deviation; IQR = interquartile rank; IAH = Intra-abdominal hypertension; COPD = chronic obstructive pulmonary disease; GI-HBP = gastrointestinal hepatobiliary and pancreas disease; Renal-GU = renal and genitourinary disease

in all new cases for 7 days or the patients were discharged or died and found 33% of the patients developed IAH after admission[9]. The incidence in this study was close to a study from Hong et al that also measured IAP in all enrolled patients but the cut point in that study was 20 mmHg which was higher than the Vidal et al study and our study[10]. The incidence of IAH in the Hong et al study was reported as 2%. Relatively, the incidence in our study was lower than in the other studies. A reason that might explain this was the protocol used in this study indicated that the intra-abdominal pressure would be done only on patients who were suspected to have IAH. The measurement was not done as a routine screening. Another possible explanation is the characteristic of SICUs in Thailand since the SICUs are department-oriented based. Patients who developed medical problems during admission into the surgical department would be admitted into the SICU. Almost one-third of the population in our study was admitted with other problems besides intra-abdominal cause and trauma. This population had a low tendency to have IAH.

Many prognostic factors for survival were demonstrated in a previous study[5]. APACHE II,

Table 2. Risk factors of mortality in the SICUs

Factors	Survive n = 54	Death n = 17	*p*-value
Male (%)	38 (70.4)	14 (82.4)	0.531
APACHE II score (IQR)	12 (7-16)	19 (14-21)	0.005
SOFA score (IQR)	6 (3.2,8)	5 (3-11)	0.802
Fluid balanced before IAH (L)	2.9 (1.0-6.3)	4.7 (2.0-9.3)	0.244
BMI >30 kg/m^2 (%)	1 (2.1)	0 (0)	1.000
Cardiac arrest before admission (%)	1 (1.9)	1 (5.9)	0.424
Post abdominal surgery (%)	36 (76.6)	10 (66.7)	0.505
Multiple trauma (%)	13 (27.7)	4 (26.7)	1.000
Abdominal ileus (%)	10 (21.3)	1 (6.7)	0.268
pH <7.2 (%)	1 (2.1)	6 (40)	<0.001
Coagulopathy (%)	8 (17)	5 (33.3)	0.272
Blood transfusion >10 Units/day (%)	11 (23.4)	6 (40)	0.318
Severe sepsis or septic shock (%)	9 (19.1)	3 (20)	1.000
Damage control surgery (%)	7 (14.9)	1 (6.7)	0.667
Abdominal aortic surgery (%)	7 (14.9)	7 (46.7)	0.028
Maximum intra-abdominal presuure (SD)	17.4 (4.7)	19.8 (6.5)	0.129

Value with SD is mean and value with IQR is median.
APACHE II score = the acute physiology and chronic health evaluation II score; SOFA = the sequential organ failure assessment score; SD = standard deviation

Table 3. Multivariable analysis for the risk factors associated with ICU mortality

Factors	Odds ratio (95% confidence interval)	*p*-value
Acidosis	22.78 (2.02-256.13)	0.01
Abdominal aortic surgery	6.28 (1.33-29.76)	0.02

APACHE II = the acute physiology and chronic health evaluation II score

SAPS II, and SOFA scores were proposed as initial prognostic factors as well as coagulopathy, sepsis, and liver dysfunction as predisposing conditions that increased the odds of mortality. Our study had different findings. We found the non-survivor group had higher APACHE II scores; however, it was not statistically significant in multivariable analysis. Metabolic acidosis was our strong predisposing factor that increased mortality since it may represent poor tissue perfusion. Acidosis was considered as a predisposing factor of IAH[6] but there was no study that reported the association with mortality in IAH patients. However, acidosis itself was reported as a risk factor of mortality in critically ill patients[11]. We did not obtain other parameters that represent tissue perfusion such as lactate or base deficit in our study.

IAH and ACS are common complications after abdominal aortic aneurysm surgery[12]. The interesting finding in our study was that abdominal aortic surgery was a significant factor for mortality in IAH patients. Previous literature showed IAH was a common complication in abdominal aortic surgery. The incidence of IAH was reported as 7.4% after endovascular repair of ruptured aortic aneurysm and 19% after open repair[13]. This study we included both endovascular and open abdominal aortic surgery together. Since the mortality rates between endovascular repair and open repair were reported to be different[14] and since both surgical techniques had an incidence of IAH[15], a future study should consider these groups separately.

A limitation of this study was the tendency

for the incidence of IAH to be under-reported since the protocol to detect IAH indicated that measurement would be done only if the patient had suspected clinical conditions such as abdominal distension. Therefore, some patients with low grade IAH possibly were not detected. According to the distribution of the cases, there were three centers that did not report any cases of IAH. There is a possibility that those centers did not measure intra-abdominal pressure which led to an under-reporting of IAH in our study.

Another limitation was we did not record the time sequence. The protocol demanded the participating investigators to record the maximum pressure that was measured during the entire episode of IAH; some patients received treatment before the measurement was performed. This may explain why 4 patients were reported to have IAH although the maximum pressure was less than 12 mmHg.

Conclusion

IAH is not a common complication in general SICU patients. However, patients should be observed closely after abdominal surgery and trauma when IAH usually occurs in these populations. Acidosis and postoperative aortic surgery were important risk factors associated with mortality in the SICU.

What is already known on this topic?

The risk of developing of IAH in surgical critically ill patients, especially in trauma and post abdominal surgery patients and also the factors associated with mortality in IAH patients have been studied before.

What this study adds?

This is the largest cohort in Thailand that presented the incidence of IAH in critically ill surgical patients who admitted in SICUs.

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Potential conflicts of interest

None.

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อุบัติการณ์และปัจจัยช่วยพยากรณ์โรคสำหรับอัตราตายในภาวะความดันในช่องท้องสูงในหออภิบาลผู้ป่วยศัลยกรรมในการศึกษา THAI-SICU

โอสรี อัครบวร, กวีศักดิ์ จิตตวัฒนรัตน์, ชนนท์ กองกมล, สุนิสา ฉัตรมงคลชาติ, ชณัฐี กิจศิริพันธ์, กลุ่มศึกษา THAI-SICU

วัตถุประสงค์: *ศึกษาอุบัติการณ์และปัจจัยช่วยพยากรณ์โรคของการเสียชีวิตในผู้ป่วยที่มีภาวะความดันในช่องท้องสูง ในหออภิบาลผู้ป่วยศัลยกรรมในประเทศไทย*

วัสดุและวิธีการ: *การศึกษานี้เป็นการศึกษาไปข้างหน้าในโรงพยาบาลมหาวิทยาลัยจำนวน 9 แห่งในประเทศไทย (THAI-SICU study) ผู้ป่วยที่มีภาวะความดันในช่องท้องสูง คือ ผู้ป่วยที่มีความดันในช่องท้องสูงกว่า 12 มิลลิเมตรปรอทจะนำเข้าสู่การศึกษานี้และจะเก็บข้อมูลต่อเนื่องไปจนกระทั่งผู้ป่วยออกจากหออภิบาล*

ผลการศึกษา: *จากผู้ป่วยทั้งหมด 4,652 ราย มี 71 ราย ที่มีภาวะความดันในช่องท้องสูง ซึ่งคิดเป็นร้อยละ 1.5 ของผู้ป่วยที่เข้ารับการรักษาในหออภิบาล อายุเฉลี่ยระหว่าง 53.05±20.26 ปี ค่ากลางคะแนน APACHE II เท่ากับ 13 (9, 15) มีผู้ป่วย 18 ราย ได้รับการรักษาด้วยการผ่าตัด ภาวะเลือดเป็นกรดและการผ่าตัดเพื่อรักษาเส้นเลือดโป่งพองในช่องท้อง เป็นปัจจัยที่มีนัยสำคัญทางสถิติในการเพิ่มโอกาสเสียชีวิตในผู้ป่วยที่มีความดันในช่องสูง*

สรุป: *อุบัติการณ์การเกิดภาวะความดันในช่องท้องสูงในการศึกษานี้เกิดขึ้นน้อย การได้รับการผ่าตัดโรคเส้นเลือดแดงโป่งพองในช่องท้องและภาวะมีเลือดเป็นกรดเป็นปัจจัยที่สัมพันธ์กับการเพิ่มขึ้นของอัตราตายในหออภิบาล*