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ORIGINAL RESEARCH **PERIOPERATIVE MEDICINE**

Intra–abdominal hypertension in critically ill patients after emergency abdominal surgery: incidence, risk factors, and patient outcome

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ABSTRACT

Background and Objectives: Intra-abdominal hypertension (IAH) is frequently encountered in patients undergoing major emergency abdominal surgery and is associated with adverse outcomes in the intensive care unit (ICU). This study aims to evaluate the prevalence, risk factors, and outcomes of IAH in a surgical ICU setting.

Methodology: This prospective observational study was conducted at the Center for Anesthesia & Surgical Intensive Care, Bach Mai Hospital, from April 2023 to September 2023. We included adult patients who underwent emergency major abdominal surgery and were in the surgical ICU for more than 48 h. Intra-abdominal pressure (IAP) was measured via a urinary bladder catheter upon ICU admission, and subsequently at 24 and 48 h. IAH was classified according to the World Society of the Abdominal Compartment Syndrome guidelines from 2013. The incidence of IAH and treatment outcomes, including the number of days on mechanical ventilation and the 28-day mortality rate, were recorded. Odds ratios (OR) and 95% CI were calculated to assess the effect size of perioperative risk factors.

Results: Among 92 patients, 38 were diagnosed with IAH. The majority of these patients had IAH grade I, (31.5%), with no cases of grade IV observed. multivariable Logistic-regression analysis revealed several risk factors for IAH included septic shock (odds ratio [OR]; 95% confidence interval [CI]: 3.31; 1.34–8.01), peritoneal fluid (5.28; 1.33–21.05), massive fluid resuscitation (6.93; 1.38–34.80), intra-abdominal infection (7.19; 2.58–20.04), and coagulopathy (3.73; 1.55–8.94). Patients with IAH had a significantly longer duration of mechanical ventilation and ICU length of stay (P = 0.009 and P = 0.049, respectively). The 28-day mortality rate was markedly higher in the IAH group compared to the non-IAH group (34% vs. 5.6%, P = 0.000). A strong correlation was observed between IAH and 28-day mortality, with each 1 mmHg increase in IAP associated with a 5.3-fold increase in mortality rate.

Conclusion: IAH is common among patients undergoing major emergency abdominal surgery and is linked to prolonged ICU stay, extended mechanical ventilation, and increased 28-day mortality. Key risk factors for IAH include septic shock, intra-peritoneal fluid collections, massive fluid resuscitation, intra-abdominal infection, and coagulopathy.

Abbreviations: ACS: Abdominal compartment syndrome, BMI: body mass index, ICU: Intensive Care Unit , IAH: Intra-abdominal hypertension, IAP: Intra-abdominal pressure, RRT: renal replacement therapy

Keywords: Intra-Abdominal Hypertension; Risk Factors; Outcome; Emergency Abdominal Surgery

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1. INTRODUCTION

Wendt E. first documented intra-abdominal hypertension (IAH) in 1976. Since then, numerous studies have explored and defined this condition in various ways. In 2013, the World Society of the Abdominal Compartment Syndrome (WSACS) established diagnostic criteria and a classification system for IAH severity, which has become the widely accepted standard.[1] Recent research indicates that IAH affects 30–85% of ICU patients. IAH is known to cause multi-organ dysfunction, prolonged ICU stays, and extended hospitalization.[2,3] In surgical patients, the incidence of IAH was higher, and may up to 65% in abdominal surgery and associated with high morbidity and mortality. IAH occurs frequently in cardiac surgery patients, with 83.3% experiencing it at least once postoperatively, and may be associated with kidney dysfunction.[4-5] Therefore, early diagnosis and targeted interventions to reduce intra-abdominal pressure (IAP) are crucial for improving both organ function and patient outcomes.[4-5] Many studies have underscored risk factors such as massive fluid resuscitation, elevated body mass index (BMI), pancreatitis, and emergency abdominal surgery.[5,6] Abdominal surgery, in particular, is frequently cited as an independent risk factor for IAH, with an even higher prevalence observed in patients experiencing septic shock.[7-10] This study focuses on patients who underwent major emergency abdominal surgery, examining the prevalence, risk factors, and outcomes associated with IAH in this population.

2. METHODOLOGY

The study was conducted in the Center for Anesthesia and Surgical Intensive Care at Bach Mai Hospital between April 2023 and September 2023. This was a prospective, observational, single-center study involving adult patients who underwent major emergency abdominal surgery and required admission to the surgical ICU. These patients had at least one criterion: an ASA ≥ 3, or in shock state, or the need for mechanical ventilation. Patients with urinarytract-related conditions such as chronic cystitis, hematuria, bladder trauma, bladder tumors, as well as those who were pregnant or admitted to the ICU for less than 48 h, were excluded from the study.

Based on Marije Smit's 2020 study,[7] we estimated the prevalence of IAH among patients to be 33%. A total of 84 patients were required for this study, as determined by the sample size calculation.

IAP was measured by the Cheatham's method,[7] upon ICU admission, after 24 h, and again at 48 h. The Cheatham bladder pressure measurement method is an indirect technique used to determine intra-abdominal pressure by measuring bladder pressure[8]. This system employs a pressure gauge fixed at a "zero" level aligned with the mid-axillary line at the iliac crest, and connects through three-way stopcocks to a Foley catheter, a 0.9% saline bag, a 50mL syringe, and the pressure measurement system. During the procedure, the patient is positioned supine with legs straight and head flat, and the perineal area is cleaned. After inserting the Foley catheter to drain all urine, 50mL of 0.9% saline is instilled into the bladder through the stopcock system. Approximately one minute later, the stopcock is opened to connect the Foley catheter to the water column, and the bladder pressure is recorded when the water column stabilizes at the end of exhalation.

The maximum IAP was determined by the highest recorded daily average during the study period. IAH was diagnosed when consecutive measurements showed an IAP ≥ 12 mmHg. If IAP reached ≥ 20 mmHg at any point, the measurement was repeated after 1 hour. In cases where

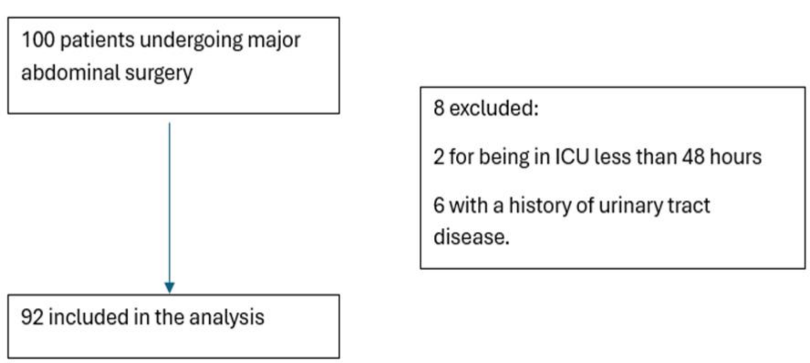

Figure 1: Flowchart of study participants

abdominal compartment syndrome (ACS) was diagnosed, the decision to intervene—whether through medical management, interventional radiology, or surgery—was left to the attending physician. Potential interventions were guided by the WSACS (World Society of the Abdominal Compartment Syndrome) recommendations for ACS management.[1] Medical management options included temporarily halting enteral feeding, inserting a nasogastric tube to drain stomach contents, increasing sedation and/or analgesia, administering neuromuscular blockers, placing a rectal cannula or enema, and removing fluids through diuretics or renal replacement therapy (RRT). Interventional radiology could involve drainage of ascites or other abdominal fluid collections, while surgical management could include surgical decompression. The severity of IAH and ACS was categorized based on the WSACS guidelines from 2013.[1]

Table 1: **Demographic characteristics and perioperative variables**

Characteristics	Categories	IAH (n= 38)	Non IAH (n = 54)	P
Sex	Male	28 (73.7)	34 (63)	0.28
	Female	10 (26.3)	20 (37)	
Age	Years	72.9 ± 13.8	67.1 ± 14.0	0.053
BMI		21.6 ± 3.0	20.7 ± 2.6	0,138
History	Hypertension	16 (42.1)	20 (37)	0.62
	Diabetes	8 (21.1)	17 (31.5)	0.26
	COPD	3 (7.9)	2 (3.7)	0.645
	CKD	4 (10.5)	1 (41.9)	0.156
SOFA score		8.6 ± 3.6	5.4 ± 3.2	0.163
SOFA score 48h		6.8 ± 4.2	3.2 ± 3.2	**0.03**
APACHE II		18.1 ± 6.9	13.9 ± 5.0	**0.011**
Mechanical ventilation		38 (100)	54 (100)	1

Values are presented as mean ± standard deviation, or number (%). P-values were determined *by t-test, chi-square test, or Fisher's exact test; COPD: Chronic Obstructive Pulmonary Disease CKD: Chronic kidney disease; SOFA: Sequential Organ Failure Assessment*

Baseline characteristics, including age, sex, body mass index (BMI), admitting diagnosis, surgical service, operative urgency, comorbidities, APACHE II score, and SOFA score, were recorded. Bladder pressure measurements were used to categorize the population into two groups: Those with IAH and those without IAH. Coagulopathy was diagnosed if one or more of the following criteria were met: platelet count < 150 G/L, prolonged prothrombin time (PT), prolonged activated partial thromboplastin time (aPTT), or decreased fibrinogen levels (< 2 g/dl). Massive fluid resuscitation was defined as a positive fluid balance exceeding 2 liters within a 24-hour period.

2.1. Statistical analysis

Data were analyzed using SPSS version 23.0. Quantitative variables were expressed as means with standard deviations and compared using the t-test for normally distributed variables and the Mann-Whitney U test for non-normally distributed variables. Qualitative variables were presented as counts (n) and percentages and analyzed using the chi-squared test. Odds ratios (OR) and 95% CI were calculated to assess the effect size of perioperative risk factors. Then we performed multiple logistic regression analysis, with IAH as dependent variables to define risk factors for its presence. Baseline variables associated with IAH in univariate analysis (using P < 0.05) were incorporated in the initial model together with variables physiologically likely to be associated with IAH. A model was then constructed by backward elimination of nonsignificant predictor variables. A multiple logistic regression analysis was conducted with IAH as the dependent variable to identify significant risk factors. Baseline variables that showed an association with IAH in univariate analysis (P < 0.05) were included in the initial multivariable model. Additionally, variables considered to have a potential physiological association with IAH were also included. The effect sizes of perioperative risk factors were evaluated using odds ratios (ORs) with corresponding 95% confidence intervals (CIs).

The univariate logistic regression model was also used to assess the relationship between 28-day survival rates and intra-abdominal pressure. P < 0.05 was considered to be statistically significant.

We conducted this study in compliance with the principles of the Declaration of Helsinki.

The study's protocol was reviewed and approved by the Bach Mai hospital Ethical Review Board vide No. 4663 QĐ/BM. Written informed consent was obtained from all of the participants or their attendants.

3. RESULTS

A total of 92 eligible patients were included in the study. The average IAP for the study population was 10.1 ± 4.5 mmHg. Among the 92 patients, 31 (33.7%) had IAH upon ICU admission, while 38 patients (41.3%) developed IAH within the first 48 h of their ICU stay. The majority of patients experienced grade I IAH (31.5%), and no cases of grade IV IAH were observed. When comparing the IAH group to the non-IAH group, no statistically significant differences were found in demographic variables such as gender, age, BMI, or comorbidities (Table 1).

Table 2: The distribution of patients according to grade of IAH

Grade of IAH	N (%)
Grade I (12-15)	29 (76.3)
Grade II (16-20)	7 (18.4)
Grade III (21-25)	2 (5.2)
Grade IV (>25)	0 (0)

However, the average APACHE II scores were significantly higher in the IAH group compared to the non-IAH group (18.2 ± 6.9 vs. 13.9 ± 5.0, P = 0.011). Additionally, 48-hour SOFA scores were significantly higher in the IAH group than in the non-IAH group (6.9 ± 4.2 vs. 3.2 ± 3.2, P = 0.03).

The majority of patients were in grade I, accounting for 76.3%, and there were no patients in grade IV (Table 2).

There are five independent risk factors associated with IAH. The odds ratio for septic shock was 3.31 (95% confidence interval [CI], 1.34–8.01); for intra-peritoneal fluid collections was 5.28 (95% CI, 1.33–21.05); for massive fluid resuscitation was 6.93 (95% CI, 1.38–34.80); for intra-abdominal infection it was 7.19 (2.58–20.04), and for coagulopathy was 3.73 (95% CI; 1.55–8.94) (Table 3).

Patients with IAH also had significantly longer durations of mechanical ventilation and ICU stays (P = 0.009 and P = 0.049, respectively). The 28-day mortality rate was markedly higher in the IAH group compared to the non-IAH group (34% vs. 5.6%, P = 0.000) (Table 4). Notably, there was a strong correlation between IAH and 28-day mortality: for every 1 mmHg increase in IAP, there was a 5.3-fold increase in the risk of mortality (Figure 2).

4. DISCUSSION

The incidence of IAH among postoperative abdominal patients in this study is 41.3%, negatively impacting patient outcomes. Independent risk factors for IAH identified include septic shock, intra-peritoneal fluid

Table 3: Independent predictors in two groups from multivariable logistic - regression analysis

Factors	IAH (n = 38)	Non IAH (n = 54)	P	OR 95% CI
Sepsis shock	28 (73.6)	22 (40.7)	0.003	3.31 (1.34−8.01)
Peritoneal fluid	9 (23.7)	3 (5.6)	0.011	5,28 (1.33−21.05)
Massive fluid resuscitation	8 (21.1)	2 (3.7)	0.008	6.93 (1.38−34.80)
Abdominal infection	32 (84.2)	23 (42.6)	0.000	7.19 (2.58–20.04)
Coagulation	24 (63.2)	17 (31.5)	0.03	3.73 (1.55 - 8.94)

Values presented as mean ± SD, or number (%); P-values were determined by *t-test,* chi-square test, or Fisher's exact test.

Table 4: The outcome for patients with intra-abdominal hypertension

Outcome	IAH	Non - IAH	P-value
Duration of mechanical ventilation (days)	7.4 ± 8.6	3.2 ± 6.5	0.009
Duration in ICU (days)	8.5 ± 8.3	5.3 ± 6.98	0.049
Mortality	13 (34)	3 (5,6)	0.000

Values are presented as mean ± standard deviation, or number (%). p-values were determined by t-test, chi-square test, or Fisher's exact test.

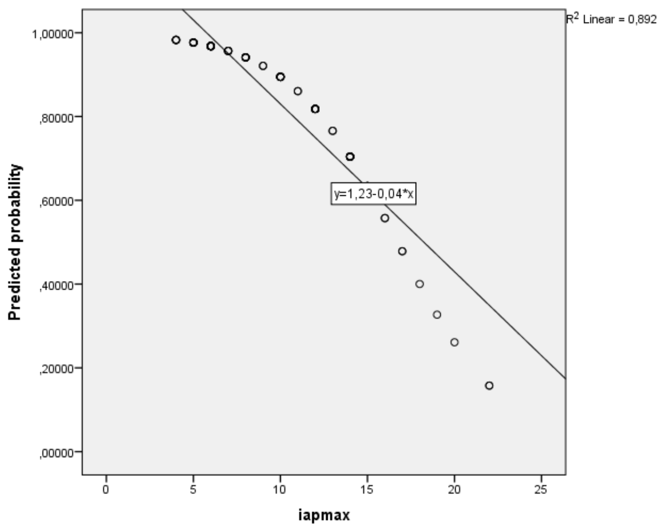

Figure 2: The relationship between intra-abdominal pressure max and survival rate

collections, massive fluid resuscitation, intra-abdominal infection, and coagulopathy.

Most studies have focused on mixed ICU patient populations, with few specifically addressing the epidemiology of intra-abdominal hypertension (IAH) in patients following abdominal surgery. For instance, Serpytis (2008) reported an IAH incidence of 40% among patients after major abdominal surgery.[11] In

another study by Kim et al. (2012), which examined a mixed ICU setting, 19 out of 37 surgical patients (45.2%) were found to have IAH[2]. These findings align closely with our study's prevalence of IAH in surgical abdominal patients, which includes both elective and emergency surgeries. It is important to differentiate between these types of surgeries. Recently, Smit et al. (2020) studied a mixed ICU population and reported IAH incidences of 17.1% for elective surgeries and 50% for emergency surgeries[6]. Notably, they identified admission to the ICU following emergency abdominal surgery as a significant risk factor for developing IAH.

The WSACS guidelines, updated in 2013, provide a comprehensive discussion of the risk factors for IAH.[1] Sepsis is a notable risk factor for IAH, as highlighted in the WSACS guidelines. Sepsis related to abdominal conditions in the surgical ICU is a serious concern and represents a significant number of cases. Previous studies have shown a clear link between sepsis, abdominal compartment syndrome (ACS), and higher IAP.[3,5,14,15] This connection is mainly due to factors like fluid resuscitation, inflammation, postoperative ileus, and increased tension in the abdominal wall after surgery. Therefore, it's important to understand how often these issues occur in patients in shock and to explore their relationships.

Massive fluid resuscitation or positive fluid balance is also an independent risk factor for IAH/ACS, as demonstrated in several studies, which is similar to our findings. Massive fluid resuscitation is believed to trigger significant inflammatory responses and increased capillary permeability, leading to diffuse tissue infiltration, cardiovascular impairment, bowel edema, and elevated IAP.[15] Research by Mindaugas Šerpytis et al. shows that IAP is sensitive to daily changes in fluid balance in patients after major abdominal surgery.[14] Effective fluid management in major abdominal surgery has been a widely debated issue, and our current goal is to implement goal-directed fluid therapy to mitigate the complications associated with restrictive or liberal fluid resuscitation methods.

Coagulation issues are another risk factor for IAH, as noted in the WSACS guidelines; however, there is limited research on the relationship between IAH and coagulopathy. A recent study indicated that disseminated intravascular coagulation (DIC) is a risk factor for developing ACS in abdominal trauma patients.[18] Additionally, we found, consistent with other studies, that intra-abdominal infections and intra-peritoneal fluid collections are significant risk factors for IAH, primarily due to their impact on increasing intra-abdominal contents. This may be the reason why we have few patients with severe IAH.

Most studies indicate that intra-abdominal hypertension (IAH) is associated with adverse outcomes and longer ICU stays; however, some single-center studies have not confirmed this finding.[3,6, 20,21] Our data supports the notion that patients with IAH experience prolonged durations of mechanical ventilation and ICU stays, along with higher mortality rates compared to those without increased intra-abdominal pressure. Notably, we found a strong correlation between the 28-day mortality rate and IAH, with a 1 mmHg increase in IAP associated with a 5.3-fold rise in mortality (as analyzed using univariate logistic regression). Additionally, the severity of IAH significantly impacts mortality rates: the patients with grade II IAH had a markedly higher mortality rate compared to those with grade I IAH. However, the limited number of patients with grade III IAH (only 2) and none with grade IV precluded a thorough analysis of these higher grades. According to a prospective multicenter study by Annika Reintam Blaser, the presence and severity of IAH during the first two weeks in the ICU significantly and independently increased 28- and 90-day mortality.[6] Importantly, this study suggested that grade I IAH (12–15 mmHg) might not increase mortality risk, indicating that lower-grade IAH may reflect the severity of underlying disease and its treatment rather than causing additional physiological harm. Thus, the severity of IAH should be carefully considered in future research and when developing treatment recommendations.

5. LIMITATIONS

Several limitations should be acknowledged in our study. First, we did not differentiate between various types of surgical operations, which prevented us from analyzing the differences in IAH rates and severity across different procedures. Second, our study did not explore treatment approaches for IAH or the causes of mortality; it primarily aimed to determine the prevalence of IAH and the associated outcomes in patients following abdominal surgery by identifying key risk factors rather than examining treatment modalities or mortality causes.

6. CONCLUSIONS

IAH is common among patients undergoing major emergency abdominal surgery and is linked to prolonged ICU stay, extended mechanical ventilation, and increased 28-day mortality. Key risk factors for IAH include septic shock, intra-peritoneal fluid collections, massive fluid resuscitation, intra-abdominal infection, and coagulopathy.

From our findings, we emphasize the importance of routinely measuring IAH in postoperative abdominal patients to ensure early detection and timely management of complications. In addition to well-known risk factors such as intra-peritoneal fluid collections and intra-abdominal infections, it is crucial to consider other complex risk factors, including septic shock, massive fluid resuscitation, and coagulopathy.

7. FUTURE PERSPECTIVE

Future research should focus on analyzing patient subgroups based on the type of surgical procedures and investigating treatment approaches and outcomes for each grade of IAH. Such studies are vital for developing specific, evidence-based treatment guidelines.

8. Data availability

The numerical data generated during this research is available with the authors.

9. Conflict of interest

The study utilized the hospital resources only, and no external or industry funding was involved.

10. Authors' contribution

NTT: conceptualization, investigation, methodology, project administration, resources, supervision, validation, writing – review and editing

VVK: data curation, formal analysis, investigation, methodology, and writing the original draft.

NTG, HSH: analysis, investigation, software, validation, and writing the original draft.

LMQ, VTQ: conceptualization, methodology, resources, supervision, review and editing.

11. REFERENCES

1. Kirkpatrick AW, Roberts DJ, et al. Intra-abdominal hypertension and the abdominal compartment syndrome: updated consensus definitions and clinical practice guidelines from the World Society of the Abdominal Compartment Syndrome. Intensive Care Med. 2013;39(7):1190-206. [PubMed] DOI: 10.1007/s00134-013-2906-z

2. Kim IB, Prowle J, Baldwin I, Bellomo R. Incidence, risk factors, and outcome associations of intra-abdominal hypertension in critically ill patients. Anaesth Intensive Care. 2012;40(1):79-89. [PubMed] DOI: 10.1177/0310057X1204000107

3. Ke L, Ni HB, Sun JK, et al. Risk factors and outcome of intra-abdominal hypertension in patients with severe acute pancreatitis. World J Surg. 2012;36(1):171-8. [PubMed] DOI: 10.1007/s00268-011-1295-0

4. Malbrain ML, Cheatham ML, Kirkpatrick A, et al. Results from the International Conference of Experts on Intra-abdominal Hypertension and Abdominal Compartment Syndrome. I. Definitions. Intensive Care Med. 2006;32(11):1722-32. [PubMed] DOI: 10.1007/s00134-006-0349-5

5. Reintam Blaser A, Regli A, De Keulenaer B, et al. Incidence, risk factors, and outcomes of intra-abdominal hypertension in critically ill patients: a prospective multicenter study. Crit Care Med. 2019;47(4):535-42. [PubMed] DOI: 10.1097/CCM.0000000000003623

6. Smit M, Koopman B, Dieperink W, et al. Intra-abdominal hypertension and abdominal compartment syndrome in patients admitted to the ICU. Ann Intensive Care. 2020;10(1):130.

7. Cheatham MD, Safcsak RN. Intra-abdominal pressure: a revised method for measurement. J Am

Coll Surg. 1998;186(3):368-9. [PubMed] DOI: 10.1186/s13613-020-00746-9

8. Reintam A, Parm P, Kitus R, Kern H, Starkopf J. Primary and secondary intra-abdominal hypertension—different impact on ICU outcome. Intensive Care Med. 2008;34(9):1624-31. [PubMed] DOI: 10.1007/s00134-008-1134-4

9. Blaser AR, Parm P, Kitus R, Starkopf J. Risk factors for intra-abdominal hypertension in mechanically ventilated patients. Acta Anaesthesiol Scand. 2011;55(5):607-14. [PubMed] DOI: 10.1111/j.1399-6576.2011.02415.x

10. Regueira T, Bruhn A, Hasbun P, et al. Intra-abdominal hypertension: incidence and association with organ dysfunction during early septic shock. J Crit Care. 2008;23(4):461-7. [PubMed] DOI: 10.1016/j.jcrc.2007.12.013

11. Serpytis M, Ivaskevicius J. The influence of fluid balance on intra-abdominal pressure after major abdominal surgery. Med Kaunas. 2008;44(6):421-7. [PubMed]

12. Cox MC, Brakenridge SC, Stortz JA, et al. Abdominal sepsis patients have a high incidence of chronic critical illness with dismal long-term outcomes. Am J Surg. 2020;220(6):1467-74. [PubMed] DOI: 10.1016/j.amjsurg.2020.07.016

13. Regueira T, Hasbun P, Rebolledo R, et al. Intra-abdominal hypertension in patients with septic shock. Am Surg. 2007;73(9):865-70. [PubMed]

14. Serpytis M, Ivaskevicius J. The influence of fluid balance on intra-abdominal pressure after major abdominal surgery. Med Kaunas. 2008;44(6):421-7. [PubMed]

15. Balogh ZJ, Martin A, van Wessem KP, et al. Mission to eliminate postinjury abdominal compartment syndrome. Arch Surg. 2011;146(8):938-43. [PubMed] DOI: 10.1001/archsurg.2011.73

16. Malbrain ML, Chiumello D, Pelosi P, et al. Incidence and prognosis of intra-abdominal hypertension in a mixed population of critically ill patients: a multicenter epidemiological study. Crit Care Med. 2005;33(2):315-22. [PubMed] DOI: 10.1097/01.ccm.0000153408.09806.1b

17. Yang TX, Tan AY, Leung WH, Chong D, Chow YF. Restricted versus liberal versus goal-directed fluid therapy for non-vascular abdominal surgery: a network meta-analysis and systematic review. Cureus. 2023;15(4):e38238. [PubMed] DOI: 10.7759/cureus.38238

18. Komori A, Iriyama H, Kainoh T, Aoki M, Abe T. Association between intra-abdominal injured organs and abdominal compartment syndrome in patients with severe blunt trauma: a propensity score-matched study using a nationwide trauma registry in Japan. PLoS One. 2023;18(5):e0286124. [PubMed] DOI: 10.1371/journal.pone.0286124

19. Vidal MG, Ruiz Weisser J, Gonzalez F, et al. Incidence and clinical effects of intra-abdominal hypertension in critically ill patients. Crit Care Med. 2008;36(6):1823-31. [PubMed] DOI: 10.1097/CCM.0b013e31817c7a4d

20. Malbrain ML, Chiumello D, Cesana BM, et al. A systematic review and individual patient data meta-analysis on intra-abdominal hypertension in critically ill patients: the WAKE-Up project. Minerva Anestesiol. 2014;80(3):293-306. [PubMed]

21. Iyer D, Rastogi P, Åneman A, D'Amours S. Early screening to identify patients at risk of developing intra-abdominal hypertension and abdominal compartment syndrome. Acta Anaesthesiol Scand. 2014;58(10):1267-75. [PubMed] DOI: 10.1111/aas.12409

