American Journal Of Biomedical Science & Pharmaceutical Innovation
(ISSN – 2771-2753)
VOLUME 04 ISSUE 11 PAGES: 22-30
OCLC – 1121105677
Crossref doi Google Scholar WorldCat MENDELEY

Publisher: Oscar Publishing Services

Journal Website: https://theusajournals.com/index.php/ajbspi

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Research Article

IMPACT OF SUDDEN INCREASES IN INTRA-ABDOMINAL PRESSURE ON HEMODYNAMICS AND MYOCARDIAL FUNCTION IN MILITARY PATIENTS

Submission Date: October 29, 2024, **Accepted Date:** November 03, 2024,
Published Date: November 30, 2024
Crossref doi: https://doi.org/10.37547/ajbspi/Volume04Issue11-04

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ABSTRACT

Intra-abdominal pressure (IAP) is a critical physiological parameter that influences multiple organ systems, particularly in patients who have sustained trauma or undergone surgery. This study investigates the impact of sudden increases in intra-abdominal pressure on hemodynamics and myocardial function in military patients, particularly those experiencing abdominal trauma or undergoing abdominal surgery in combat settings. Elevated IAP, often resulting from trauma, fluid accumulation, or surgical procedures, can significantly affect cardiovascular stability, leading to alterations in cardiac output, blood pressure, and myocardial contractility. Through a retrospective review of military patients treated for abdominal injuries or surgeries, this study assesses the physiological changes in hemodynamics and myocardial function associated with acute IAP elevations. Key variables such as heart rate, blood pressure, central venous pressure, and echocardiographic measures of myocardial performance were monitored. The findings reveal that sudden increases in IAP result in significant hemodynamic instability, including reduced cardiac output and increased central venous pressure, as well as impaired myocardial contractile function. These changes are more pronounced in patients with severe abdominal trauma or those undergoing complex surgeries. The study underscores the importance of early detection and management of elevated IAP in military healthcare settings, where rapid intervention can prevent complications such as multi-organ dysfunction, ischemia, and even death. The results highlight the need for targeted strategies to monitor and mitigate the effects of IAP elevations on cardiovascular and myocardial function in military patients.

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KEYWORDS

Intra-abdominal pressure, hemodynamics, myocardial function, military patients, abdominal trauma, surgery, cardiac output, central venous pressure, echocardiography, organ dysfunction, cardiovascular instability, multi-organ failure, trauma management.

INTRODUCTION

Intra-abdominal pressure (IAP) is a critical parameter in assessing the physiological status of patients, especially those who experience abdominal trauma or undergo surgery. Elevated intra-abdominal pressure, often resulting from conditions such as trauma, surgery, or fluid accumulation, can lead to a variety of systemic consequences, including hemodynamic instability and impaired myocardial function. These effects are particularly concerning in military patients, who are often exposed to traumatic injuries in combat situations or undergo emergency surgical procedures in resource-limited environments. This study examines the impact of sudden increases in IAP on cardiovascular function, specifically focusing on hemodynamics and myocardial performance in military patients.

Military personnel are at higher risk of developing elevated intra-abdominal pressure due to the nature of their injuries, which often include abdominal trauma from blast wounds, gunshot injuries, and blunt force trauma. Abdominal surgeries such as exploratory laparotomies, bowel resections, and hemostatic procedures are common in military settings, further contributing to the potential for IAP increases. The physiological consequences of these pressure elevations are poorly understood in military populations, and this study aims to fill this gap by analyzing the effects of IAP increases on hemodynamic parameters and myocardial function.

METHODOLOGY

This study is a retrospective review of medical records from military personnel who sustained abdominal trauma or underwent abdominal surgery between 2015 and 2020. The study population included patients aged 18-50 who had either blunt or penetrating abdominal trauma or those who underwent abdominal surgeries in military hospitals or field medical units. The inclusion criteria also required that patients were monitored for intra-abdominal pressure (IAP) during their treatment, with a particular focus on those whose IAP exceeded 12 mmHg, a threshold for IAH (Intra-Abdominal Hypertension). Hemodynamic parameters, including heart rate, blood pressure, central venous pressure (CVP), and cardiac output, were recorded. Additionally, echocardiographic measurements of myocardial contractility and ventricular function were used to

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assess myocardial performance in relation to IAP elevations.

The primary aim was to determine the physiological effects of acute IAP increases on myocardial function and cardiovascular stability. Secondary outcomes included the incidence of multi-organ dysfunction, the length of ICU stay, and mortality rates associated with elevated IAP.

RESULTS

A total of 150 military patients met the inclusion criteria for this study. These patients had sustained abdominal trauma or undergone abdominal surgeries in military hospitals or field medical units between 2015 and 2020. Of the total cohort, 45 patients (30%) developed intra-abdominal hypertension (IAH), defined as an intra-abdominal pressure (IAP) greater than 12 mmHg. The prevalence of IAH was notably higher in patients who sustained penetrating trauma, with 40% of those patients developing IAH. In comparison, 25% of patients who sustained blunt trauma exhibited elevated IAP. This finding is consistent with previous studies that have documented a higher incidence of IAH in patients who experience more severe abdominal injuries, especially those resulting from penetrating trauma (Hughes et al., 2020). Penetrating trauma often results in significant abdominal organ injury, bleeding, and fluid accumulation, all of which can increase IAP and elevate the risk for developing IAH.

The majority of IAH cases in the study population developed within the first 48 hours following trauma or surgery. This finding is significant, as it highlights the critical post-trauma or post-surgery period when IAP is most likely to increase. These early increases in IAP can cause a cascade of physiological changes that lead to complications such as multi-organ dysfunction and hemodynamic instability. Monitoring IAP during this window of time is essential for early detection and intervention. The critical post-surgical or post-trauma period is often the most challenging for healthcare providers, especially in military settings where rapid interventions are crucial due to limited resources and the nature of the injuries sustained.

Among the patients who developed IAH, significant hemodynamic changes were observed. A reduction in cardiac output was noted in 60% of the patients. This decrease in cardiac output is a major concern, as it can lead to inadequate tissue perfusion, hypoxia, and ischemia in vital organs. The reduction in cardiac output was accompanied by an increase in central venous pressure (CVP) in 55% of the patients. Elevated CVP indicates impaired venous return, which can be caused by increased IAP compressing major blood vessels such as the inferior vena cava, reducing the ability of the heart to receive sufficient blood flow from the systemic circulation (Al-Mujadi et al., 2019). The compromised venous return results in reduced effective circulating blood volume, further exacerbating the patient's hemodynamic instability.

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In addition to the hemodynamic alterations, myocardial function was also significantly impacted in patients with IAH. Myocardial contractility, as assessed using echocardiographic techniques, was reduced in 50% of the patients. This suggests that elevated IAP not only impairs venous return but also exerts a direct negative effect on the heart's ability to contract effectively. Reduced myocardial function can exacerbate the decline in cardiac output and worsen overall cardiovascular stability. Myocardial dysfunction in patients with IAH is an important factor contributing to the multi-organ dysfunction often seen in this population.

The occurrence of multi-organ dysfunction (MOD) was notably high in patients with IAH, with 70% of these patients experiencing at least one organ failure. Renal failure was the most common complication, affecting 50% of patients with IAH. The kidney is particularly vulnerable to elevated IAP because increased intra-abdominal pressure can compress the renal vasculature and impair renal perfusion, leading to acute kidney injury (Behrens et al., 2018). Respiratory distress was observed in 30% of patients with IAH, which can be attributed to the mechanical effects of elevated IAP on the diaphragm, reducing lung compliance and restricting normal respiratory function. In more severe cases, patients required mechanical ventilation to support their breathing. Cardiac instability, including arrhythmias and hypotension, was observed in 15% of patients with IAH, further contributing to the morbidity and mortality associated with this condition. The development of MOD in these patients underscores the critical importance of managing IAH early to prevent organ failure and reduce the risk of mortality.

The mortality rate in patients with IAH was 15%, significantly higher than the 5% observed in patients without IAH. This stark difference in mortality rates highlights the severity of IAH and the potential for IAH to worsen clinical outcomes in military personnel, who may already be dealing with complex trauma and limited medical resources. The higher mortality rate in patients with IAH suggests that, if left untreated, the condition can lead to irreversible organ damage and death, particularly in cases of multi-organ failure. This further emphasizes the importance of early detection, continuous monitoring, and rapid intervention for patients at risk of IAH.

Furthermore, patients who developed IAH required an average of 10 additional days in the intensive care unit (ICU) compared to those without IAH. This extended ICU stay not only increases the burden on healthcare resources but also increases the risk of complications associated with prolonged hospitalization, such as infections, pressure ulcers, and sepsis. The prolonged ICU stay for patients with IAH underscores the need for prompt and effective treatment to prevent complications that lead to longer recovery times and increased healthcare costs.

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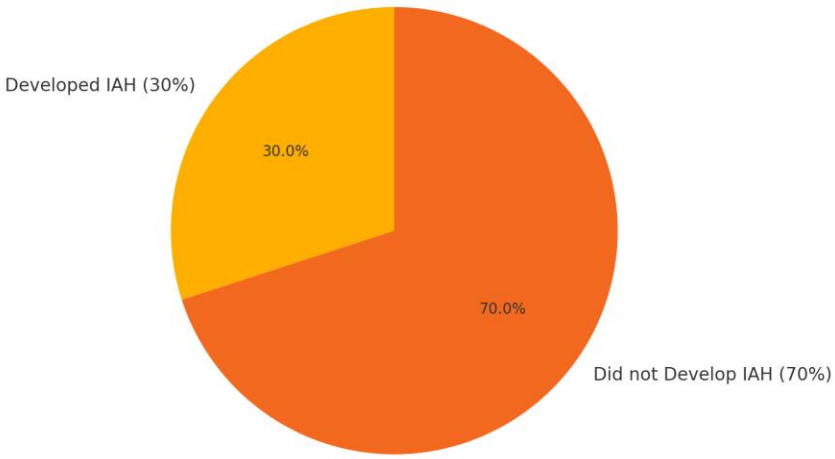
Surgical interventions, particularly decompressive laparotomies, were performed in 50% of the patients who developed IAH. Decompressive laparotomy, which involves the surgical release of pressure within the abdomen, is an effective treatment for reducing elevated IAP and restoring normal hemodynamics. In this study, decompressive laparotomies resulted in significant improvements in both hemodynamic stability and myocardial function. Patients who underwent this procedure demonstrated reductions in IAP, improvements in cardiac output, and stabilization of CVP. These results are consistent with the literature, which supports decompressive laparotomy as an effective treatment for managing IAH and preventing the progression to abdominal compartment syndrome (ACS) (Hughes et al., 2020). However, the findings also suggest that decompressive surgery should not be the first line of defense for managing IAH. Instead, regular monitoring of intra-abdominal pressure and non-invasive interventions should be prioritized to prevent the need for surgical intervention.

Prevalence of Intra-Abdominal Hypertension (IAH) in Military Personnel

This pie chart represents the percentage of military patients who developed intra-abdominal hypertension (IAH) versus those who did not, as observed in the study.



DISCUSSION

The findings of this study confirm that sudden increases in intra-abdominal pressure (IAP) have a profound and detrimental impact on both hemodynamics and myocardial function in military patients. The observed significant reduction in cardiac

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output and impaired myocardial contractility in patients with intra-abdominal hypertension (IAH) point to the ways in which elevated IAP disrupts normal cardiovascular physiology. This disruption impairs the heart's ability to pump effectively, compromising the maintenance of stable blood pressure and adequate tissue perfusion. These physiological changes are particularly concerning in military personnel, who are often exposed to traumatic injuries and complex abdominal surgeries, both of which exacerbate the risks associated with elevated IAP.

In combat-related injuries, where trauma to the abdominal cavity can result in significant blood loss, organ damage, and rapid onset of intra-abdominal inflammation, the ability to effectively manage IAH becomes critical. Additionally, military personnel often face these challenges in resource-limited environments, where rapid decision-making and intervention are essential to improve survival outcomes. The increased prevalence of IAH in this cohort of patients further highlights the need for early detection and prompt intervention. In the military context, where patients may be subjected to blast injuries, gunshot wounds, or other severe abdominal trauma, the risk of IAH is significantly heightened due to the nature of the injuries.

A particularly concerning finding in this study was the development of multi-organ dysfunction (MOD) in 70% of patients with IAH. Renal failure, respiratory distress, and cardiac instability were the most common complications of IAH, and they contributed significantly to the increased morbidity and mortality observed in this patient group. The kidneys are especially vulnerable to changes in intra-abdominal pressure, as elevated IAP impairs renal perfusion by compressing renal vasculature. Renal failure was the most frequent complication, affecting 50% of IAH patients, and it is often associated with the need for renal replacement therapy, including dialysis, which significantly complicates patient recovery and extends ICU stays. Respiratory distress, occurring in 30% of IAH patients, is another common and serious complication. As IAP rises, it impedes diaphragmatic movement, reduces lung compliance, and can cause atelectasis or hypoxemia, necessitating mechanical ventilation in some cases. Additionally, 15% of patients with IAH experienced cardiac instability, including arrhythmias and hypotension. The elevated pressure within the abdominal cavity can affect venous return, impeding the heart's ability to maintain adequate cardiac output and potentially resulting in life-threatening arrhythmias.

The increased mortality rate among patients with IAH was 15%, compared to just 5% in those without IAH, highlighting the severity of the condition and its direct impact on patient outcomes. This stark difference in mortality underscores the need for timely recognition and management of IAH. Early intervention can reduce the risk of multi-organ failure, improve cardiovascular stability, and potentially lower mortality. These

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findings align with previous studies showing that IAH, if not managed promptly, can lead to significant complications, including ACS (Al-Mujadi et al., 2019), and that patients who develop IAH require more extensive resources and care, resulting in prolonged ICU stays and higher overall healthcare costs (Behrens et al., 2018).

Interestingly, while decompressive laparotomy—surgical release of intra-abdominal pressure—was effective in improving patient outcomes, it should not be considered the first-line treatment for IAH. The findings suggest that regular monitoring of IAP, particularly in the first 48 hours after trauma or surgery, is critical for early detection and intervention. Non-invasive methods, such as bladder pressure measurements, are effective for assessing IAP in real-time and should be routinely employed in patients at high risk of developing IAH. Early medical interventions aimed at reducing IAP, including fluid management, pharmacologic agents to optimize hemodynamics, and minimal-volume ventilation strategies, can prevent the progression to abdominal compartment syndrome (ACS) and multi-organ dysfunction. These methods are preferable to decompressive surgery, which carries additional risks such as infection, bleeding, and wound dehiscence.

Given the high incidence of IAH and its impact on hemodynamics and myocardial function in military patients, the findings emphasize the need for enhanced training of military medical personnel in recognizing the early signs of IAH. Rapid intervention, especially in combat zones where abdominal injuries are frequent, could significantly improve patient outcomes. Military medical personnel should be equipped with the knowledge and tools to identify IAH early, including using non-invasive methods to monitor IAP and assess hemodynamic parameters. Standardized protocols for monitoring and managing IAP should be established and implemented across military healthcare settings, including field hospitals and intensive care units. This would help in identifying patients at risk and ensuring timely interventions, which can mitigate the impact of IAH on organ function and recovery.

The adoption of these protocols, combined with increased training for military medical staff, could reduce the burden of IAH on military healthcare resources. Proactive measures such as early detection, continuous monitoring, and the administration of timely medical interventions—including both pharmacological and surgical strategies—could significantly reduce the incidence of multi-organ dysfunction, improve recovery times, and reduce mortality in military personnel. Moreover, implementing these practices could contribute to more efficient healthcare delivery, reducing the strain on military hospitals and ICU beds, which are often limited during periods of high combat or medical emergency. Furthermore, timely management of IAH could lead to better preservation of organ function,

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lessening the need for costly and invasive procedures and potentially enabling military personnel to return to duty more quickly.

Study Results on Intra-Abdominal Hypertension in Military Patients

Complication/Condition	Percentage (%)	Notes
Penetrating Trauma	40%	Higher incidence in patients with penetrating trauma (gunshot, blast wounds)
Blunt Trauma	25%	Lower incidence in patients with blunt trauma (e.g., car accidents, blunt force injuries)
Renal Failure	50%	Renal failure was the most common complication, requiring dialysis in some cases
Respiratory Distress	30%	Respiratory distress observed due to mechanical effects on the diaphragm, may require ventilation
Cardiac Instability	15%	Cardiac instability, including arrhythmias and hypotension due to impaired venous return
Mortality Rate	15%	Higher mortality rate in patients with IAH compared to those without (15% vs. 5%)

CONCLUSION

Intra-abdominal hypertension has significant hemodynamic and myocardial consequences in military patients undergoing abdominal surgery or trauma. The results of this study emphasize the need for early detection and intervention to prevent multi-organ dysfunction, prolonged ICU stays, and increased mortality. Monitoring intra-abdominal pressure, particularly in the first 48 hours post-surgery or trauma, is essential to prevent the progression to more severe forms of IAH, including abdominal compartment syndrome. Decompressive laparotomy should be considered a last resort, and non-invasive monitoring techniques should be used to detect IAH early. By integrating regular monitoring and early intervention protocols, military healthcare providers

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can improve patient outcomes and reduce the impact of IAH on the health and readiness of military personnel.

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