Bladder Pressure Measurements in Patients Admitted to a Medical Intensive Care Unit

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Abstract: *Background:* Intra-abdominal hypertension is identified as an independent risk factor for death. However, this pathophysiological state is not always considered in patients in medical intensive care units and is frequently underdiagnosed. *Methods:* Serial bladder pressure measurements were recorded in patients admitted to the medical intensive care units to determine the frequency of intra-abdominal hypertension. *Results:* This study included 53 patients with a mean age of 59.0 ± 17.7 years. The average admission intra-abdominal pressure was 10.0 ± 5.4 mm Hg with a range of 0 to 28 mm Hg. Eleven patients (21%) had an initial pressure reading above normal (>12 mm Hg). Peak airway pressures were higher, and PaO_2/FiO_2 ratios were lower in patients with an initial pressure >12 mm Hg. *Conclusions:* Bladder pressure measurements provide an easy method to estimate intra-abdominal pressures and provide an additional tool for the physiologic assessment of critically ill patients.

Key Indexing Terms: Intra-abdominal hypertension; Abdominal compartment syndrome; Medical intensive care; Bladder pressure measurement. **[Am J Med Sci 2015;350(3):181–185.]**

Compartment syndrome refers to a fixed compartment that becomes subject to increased pressure, leading to ischemia and organ dysfunction. It occurs frequently in the extremities but can also occur in the abdomen and possibly the intracranial cavity. Abdominal compartment syndrome (ACS) is defined as the adverse physiologic consequences associated with an acute increase in intra-abdominal pressure (IAP). The consensus statement from the World Society of the Abdominal Compartment Syndrome (WSACS) defines intra-abdominal hypertension (IAH) as an IAP ≥12 mm Hg and ACS as a sustained IAP ≥20 mm Hg associated with new organ dysfunction or failure.[1,2] ACS has a complex pathophysiology, which includes compression of vessels and intra-abdominal organs. Vascular compression reduces arterial perfusion and venous drainage from the intestine and kidneys. Organ dysfunction also occurs because there is direct compression of the intestine.[3] These structures collapse under high pressures, and thrombosis and bowel wall edema occur leading to translocation of bacterial products and additional fluid accumulation, which further increases IAPs. At the cellular level, oxygen delivery is impaired, which causes ischemia and anaerobic metabolism. Vasoactive substances, such as histamine and serotonin, increased endothelial permeability, and capillary leakage also contribute to interstitial and cellular edema and impaired oxygenation.

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Most of the articles published on IAH and ACS have focused on surgical patients or patients with trauma. Few studies have been done exclusively on patients in medical intensive care units (MICU). Malbrain et al determined the prevalence of IAH and its risk factors in a mixed population of intensive care unit patients. They enrolled 97 patients in 13 ICUs.[4] Thirty-one of these patients had bladder pressures >12 mm Hg and were in the MICU. A 2nd study on IAH/ACS in MICU patients was done in 2006, and these investigators evaluated patients receiving large volume resuscitation; 34 of the 40 patients included had IAH and 13 had ACS. The median positive fluid balance in this study was 6.9 L. The common risk factors for IAH include obesity, sepsis/infection, abdominal surgery, acidosis, hypotension, mechanical ventilation and fluid resuscitation.[5] The WSACS has published an algorithm with risk factors of IAH/ACS and recommends monitoring bladder pressures if more than 2 risk factors exist. The authors conducted a study to determine how often IAH/ACS occurred and which patients were at higher risk in their MICU patients.

METHODS

Setting

This study was conducted in the MICU at University Medical Center (UMC) in Lubbock, TX, which is a tertiary care teaching hospital associated with Texas Tech University Health Sciences Center in Lubbock. The MICU has 32 beds and manages patients with diverse medical problems, including acute respiratory failure, who may require either noninvasive or invasion mechanical ventilation.

Inclusion Criteria

All patients aged 18 to 89 admitted to MICU with a Foley catheter were screened for risk factors for IAH (Table 1). Medical records were reviewed by one author (E. A.) to determine the number of risk factors. If 2 or more risk factors were identified, the patient or the family was asked to participate in the study. Only patients who consented were included in the study. Screening took place between January 3, 2011, and December 31, 2011.

Exclusion Criteria

Patients with one or no risk factors for IAH, patients without urinary catheter, and patients with neurogenic bladder or with bladder trauma.

After entry into the study, medical records were reviewed to document risk factors for IAH, and a data collection sheet was completed (see Data Collection). This study was approved by the institutional review board at Texas Tech University Health Sciences Center in Lubbock, TX, and patients or their authorized medical decision makers gave written and informed consent.

TABLE 1. Risk factors

List of risk factors for IAH/ACS in nonsurgical patients
High BMI (>35) with central obesity
Gastroparesis/gastric distention/ileus
Acute pancreatitis
Hemoperitoneum/pneumoperitoneum
Intra-abdominal infection/abscess
Intra-abdominal or retroperitoneal tumors
Liver dysfunction/cirrhosis with ascites
Acidosis
Coagulopathy
Hypotension/shock
Hypothermia
Massive transfusion (>10 units in 24 hr)
Massive fluid resuscitation (>5 L/24 hr)
Pancreatitis
Oliguria
Sepsis

Data Collection

Age, sex, admitting diagnosis, pre-existing comorbidities, weight, height, BMI, IAP at the start of the study, mean arterial pressure (MAP), central venous pressure (CVP) when available, Glasgow coma scale, fluid balance, creatinine, bilirubin, platelet count, abdominal perfusion pressure (MAP − IAP), filtration gradient (MAP − 2 IAP), transfusions, peak airway pressures, PaO_2/FiO_2, SOFA, and APACHE II scores were recorded for each patient. This information was collected prospectively.

Measurement of IAP

Bladder pressure was measured every 4 hours and every hour for 4 readings after any of the following interventions: fluid administration, blood product administration, vasoactive drug use, paracentesis and surgical procedures, using a commercial device (AbViser AutoValve; Salt Lake City, UT, now owned by ConvaTec, Oklahoma City, OK). These measurements were made by the nurses caring for the patients; they had been given in-services to explain the technique and related measurement details. Measurements were taken at end-expiration with the patient supine. The transducer was placed at the level of the ileac crest in the midaxillary line. Each time a measurement was indicated, 20 mL of normal saline was instilled into the bladder. No medications were given to any patients specifically to take these measurements, and in particular, patients did not receive paralytic agents, sedatives or narcotics before measurement as per the 2013 WSACS update consensus definition and clinical practice guideline.[2] Measurements were recorded for 72 hours or until death, transfer out of the MICU or discontinuation of the bladder catheter.

Statistical Analysis

Data were summarized with means, SD, medians and frequencies (with percentages). Significant factors identified by univariate analysis at the 0.05 level were entered into multivariable linear regression models to identify independent factors associated with higher bladder pressure readings. SSPS 17.0.3 (IBM Inc, Chicago, IL) was used for all calculations. $P \leq 0.05$ was considered significant.

RESULTS

This study included 53 patients. The mean age was 59.0 ± 17.7 years; 55% were women. The mean body mass index was 28.0 ± 10.0 kg/m^2. The frequency of the various risk factors that were associated with IAH is summarized in Table 2. The average initial IAP was 10.0 ± 5.4 mm Hg with a range of 0 to 28 mm Hg. The number of recordings per patient, the duration of recording, the minimum and maximum pressures and 2 pressure gradients are presented in Table 3. The patients had an average of 11 recordings with a range of 3 to 29. The mean minimum IAP was 5 mm Hg; the mean maximum IAP was 15 mm Hg. Patients were stratified based on the maximum recorded IAP into the following groups: normal (<7 mm Hg), borderline (8–11 mm Hg), grade I IAH (12–15 mm Hg), grade II IAH (16–20 mm Hg), grade III IAH (21–25 mm Hg) and grade IV IAH (>25 mm Hg). Table 4 provides a classification of IAPs in these patients by category; 42% had a maximum pressure greater than 16 mm Hg. Figure 1 displays a histogram with all bladder pressure measurements; Figure 2 plots the number of risk factors versus the IAH grade. Serial measurements varied more in patients with grade III and IV IAH than in patients with normal or borderline IAP pressures (data not shown).

Univariate analysis indicated that ileus, ascites/liver dysfunction, hypotension, the total number of risk factors, the maximum CVP and positive fluid balance for the last 24 hours had a significant association with the maximum IAP (Table 5). Multivariate analysis indicated that CVP was the strongest predictor of maximum IAP. When these data were reanalyzed excluding the CVP to explore clinical factors alone, ascites/liver dysfunction and hypotension significantly predicted IAP. Univariate analysis of all 605 individual pressure recordings indicated that fluid balance (milliliter per 24 hours), peak airway pressure (centimeter H_2O) and creatinine level (in milligram per deciliter) were significantly associated with an elevated IAP. Multivariate analysis using these 3 factors indicated that only peak airway pressure was significantly associated with IAP measurements (Table 6).

TABLE 2. Frequency of risk factors for IAH

Risk factor	Percent patients (%) with risk factor
Mechanical ventilation	79
Sepsis	68
Hypotension	60
High body mass index (>30)	43
Bacteremia	23
Acute respiratory failure	23
Coagulopathy	23
Ascites and liver dysfunction	11
Acidosis	11
Oliguria	9
Ileus	8
Intra-abdominal tumors	4
Polytransfusion	2
Massive fluid administration	2

N = 53. No patients had hemoperitoneum, hypothermia, peritonitis, pancreatitis, damage control laparotomy, abdominal surgery with tight closure, major trauma or burns, prone positioning, gastroparesis or colonic pseudo-obstruction.