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# Intra-abdominal hypertension in the critically ill: Interrater reliability of bladder pressure measurement☆,☆☆

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**Abstract**

**Purpose:** Intra-abdominal hypertension is frequently underdiagnosed and defined by intra-abdominal pressure (IAP) 12 mm Hg or higher. Increasing IAP may compromise organ viability and culminate in abdominal compartment syndrome. Bladder pressure measurement is a surrogate for IAP, but measurement properties are unknown in the intensive care unit. Our primary objective was to assess the agreement of bladder pressure measurements in critically ill patients.

**Methods:** We conducted an observational study examining the correlation of measurement variability of bladder pressure. Four raters (2 nurses and 2 physicians) measured IAP. Patient's age, Acute Physiology and Chronic Health Evaluation II, body mass index, mechanical ventilation parameters, and demographics were collected.

**Results:** Fifty-one patients had bladder pressures measured in quadruplicate, producing 204 measurements. Among 51 patients, the mean age was 61.9 years, Acute Physiology and Chronic Health Evaluation II was 23.8, and body mass index was 27.8 kg/m$^2$. The average bladder pressure was 12.4 (SD, ±6.2) mm Hg. The interrater agreement by intraclass correlation coefficient was 0.745 (95% confidence interval [CI], 0.637-0.825), 0.804 (95% CI, 0.684-0.882), and 0.626 (95% CI, 0.428-0.767) among all raters, physicians, and nurses, respectively.

**Conclusions:** Agreement on bladder pressure was high among 4 clinicians and were not significantly different between physicians and nurses. Given that medical/surgical treatments are considered on bladder pressure values, understanding their reliability is essential to monitor critically ill patients.


☆ Competing interests: The authors declare no competing interests.

☆☆ Authors' contributions: CK and DJC conceived of the study, designed it, and drafted the report. TP and MS advised on data collection and interpretation. CK, NH, and DJC participated in data acquisition and measurements. CY performed the statistical analysis and aided data interpretation. All authors read, contributed to, and approved the final manuscript.

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## 1. Introduction

First described by Wendt in 1876 [1], intra-abdominal hypertension (IAH) represents a potentially serious condition that is frequently underdiagnosed despite a high estimated prevalence of 18% to 81% in the intensive care unit (ICU) [2]. Normal intra-abdominal pressure (IAP) is 5 to 7 mm Hg, and new literature indicates that up to 10 mm Hg is normal in the critically ill population [3-5]. According to the *World Society of Abdominal Compartment Syndrome* (*WSACS*) [6], IAH is defined as an IAP greater than 12 mm Hg [6]. Intra-abdominal pressure exists as a graded pathology, culminating in life-threatening abdominal compartment syndrome (ACS). Abdominal compartment syndrome occurs when IAP exceeds 20 mm Hg in association with new organ dysfunction [7].

Critically ill patients are at particularly high risk for developing IAH and ACS due to a multitude of known risk factors such as abdominal surgery, trauma, high-volume resuscitation, and hypoalbuminemia [7]. However, because of the insidious onset and nonspecific presentation of IAH, a high degree of suspicion is required to diagnose and implement timely therapy. Given the poor sensitivity of clinical examination in detecting elevated IAP and the benefit of early detection and treatment, the ability to rapidly and accurately determine IAH is important [8,9].

To aid early diagnosis, intravesicular bladder pressure measurements have been widely adopted as a surrogate for IAP [10]. Originally described by Kron et al [11], bladder pressure measurements using the patient's indwelling urinary catheter have been previously studied [12-15] but not comprehensively evaluated in an ICU setting. The exercise of measuring bladder pressure is widely accepted, as most ICU patients already have in situ Foley catheters, and it is a relatively innocuous bedside procedure. The primary objective of this study was to estimate the interrater agreement on bladder pressure measurements in critically ill patients among 4 independent clinicians.

## 2. Methods

Four independent clinicians measured bladder pressure in medical-surgical critically ill patients over a period of 4 months in a 19-bed ICU. A second-year medical resident, an ICU resident or ICU attending, a nurse coordinator (not caring for the patient that day), and a bedside ICU nurse directly involved in the patient's care examined and measured the same ICU patient within 10 minutes of each other. All clinicians were blinded to each other's measurements. All bedside nurses received bladder pressure training as an in-service by our nurse educator before the study. Before the study began, all participating clinicians were educated with the American Association of Critical-Care Nurses protocol [16] on bladder pressure measurement. During this education and training session, the technical focus was on patient recumbency and relaxation, sterile technique, instillation volume, and proper zero reference points.

Inclusion criteria consisted of patients with an indwelling urinary catheter admitted to the medical-surgical ICU, older than 18 years, and projected duration of invasive mechanical ventilation of greater than 48 hours. Patients were excluded if they did not have urethral catheterization or if they had a contraindication to being moved frequently or placed in the supine position. Patients were excluded if their Richmond Agitation/Sedation Score (RASS) was more than 1. Richmond Agitation/Sedation Score is a 10-point scale, with 4 levels denoting agitation (1-4 points), 1 level for awake and alert (0), and 5 levels of sedation (−1 to −5 points); the RASS has been extensively validated in the ICU setting [17]. We used the exclusion criterion of RASS more than 1 to enroll sedated patients whose abdominal muscle contractions were minimal or absent, to avoid falsely elevated IAP by muscle contraction, forced expiration, auto–positive end-expiratory pressure (PEEP), or pain. We used these broad criteria to enroll a variety of patients with a wide range of bladder pressures and underlying acute and chronic illnesses.

All patients had a standard 2-way urethral Foley catheter. Patients were placed in the supine position, and 25 mL of saline was instilled into the bladder via a urethral catheter port. The catheter was clamped distal to the sampling port. All measurements used a needleless system in the sampling port and a standard bedside transducer. The zero reference point was taken as the level of the superior iliac crest at the midaxillary line. This zero reference point has been shown in previous studies to have significant impact on bladder pressure measurements, and the iliac crest as a reference point provides the most accurate IAP measurements [18]. Each clinician was asked to appropriately position the patient in the supine position and determine the zero reference point independent of and blinded to other raters. The patient was moved back to their normal position (either seated or with the head of bed elevated to 30°-45° from the horizontal) so that each rater would be required to properly position the patient before measurement. Only bladder instillation volume (25 mL of sterile saline) was kept standard between raters. Because bladder pressure increases with inspiration and decreases with expiration, we instructed clinicians to attempt to measure at end-expiration. The pressure was measured approximately 30 to 60 seconds after instillation of saline to allow bladder detrusor muscle relaxation.

Each participating clinician was instructed to maintain sterile technique throughout the measurement procedure to minimize the risk of infection. All supplies were discarded once bladder pressure measurement was complete for each patient. No measurements were communicated to the ICU team so that practice was not influenced. Each participating clinician was asked to only take 1 measurement. However, if their technique did not produce a measurement, they were permitted to repeat it. The number of attempts by each clinician was also documented.