

## IS CLINICAL EXAMINATION AN ACCURATE INDICATOR OF RAISED INTRA-ABDOMINAL PRESSURE IN CRITICALLY INJURED PATIENTS?

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**OBJECTIVES:** To determine the rate of elevated intra-abdominal pressure (IAP) and to evaluate the accuracy of clinical abdominal examination in the assessment of IAP in the critically injured trauma patient.

**DESIGN:** A prospective blinded study.

**SETTING:** The medical-surgical critical care unit of a university-affiliated regional adult trauma centre.

**PATIENTS:** Forty-two adult blunt trauma victims, who had a mean injury severity score of 36.

**INTERVENTIONS:** Urinary bladder pressure was measured daily and classified as normal (10 mm Hg or less), elevated (more than 10 mm Hg) or significantly elevated (more than 15 mm Hg). A blinded clinical assessment of abdominal pressure was concurrently performed and recorded as elevated or normal.

**MAIN OUTCOME MEASURES:** The sensitivity, specificity and accuracy and the positive and negative predictive values of the 2 interventions in identifying elevated IAP.

**RESULTS:** Twenty-one patients (50%) had an elevated IAP at some point during the study. Of the 147 bladder pressure measurements done in these 42 patients, 47 (32%) were more than 10 mm Hg and 16 (11%) were more than 15 mm Hg. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of clinical abdominal examination for identifying elevated IAP were 40%, 94%, 76%, 77% and 77%, respectively. Clinical abdominal examination had a sensitivity, specificity, positive predictive value, negative predictive value and accuracy of 56%, 87%, 35%, 94% and 84% respectively, for significantly elevated IAP.

**CONCLUSIONS:** Urinary bladder pressure was commonly elevated among our population of critically injured adults. Compared with bladder pressure measurements, clinical abdominal assessment showed poor sensitivity and accuracy for elevated IAP. These findings suggest that more routine measurements of bladder pressure in patients at risk for intra-abdominal hypertension should be performed.

**OBJECTIFS :** Déterminer le taux de pression intra-abdominale (PIA) élevée et évaluer l'exactitude de l'examen abdominal clinique dans l'évaluation de la PIA chez le patient victime d'un traumatisme critique.

**CONCEPTION :** Étude prospective à l'insu.

**CONTEXTE :** Unité de soins médico-chirurgicaux critiques d'un centre régional pour traumatisés adultes affilié à une université.

**PATIENTS :** Quarante-deux adultes traumatisés victimes de contusions dont l'indice moyen de gravité des traumatismes s'établissait à 36.

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**INTERVENTIONS :** On a mesuré tous les jours la pression de la vessie pour la classer comme normale (10 mm Hg au moins), élevée (plus de 10 mm Hg) ou très élevée (plus de 15 mm Hg). On a procédé en même temps à une évaluation clinique à l'insu de la pression abdominale qui a été consignée comme étant élevée ou normale.

**PRINCIPALES MESURES DE RÉSULTATS :** Sensibilité, spécificité, exactitude, valeur prédictive positive et valeur prédictive négative des deux interventions dans l'identification d'une PIA élevée.

**RÉSULTATS :** Vingt-et-un patients (50 %) ont présenté une PIA élevée à un moment donné au cours de l'étude. Sur les 147 mesures de pression de la vessie effectuée chez ces 42 patients, la pression dépassait 10 mm Hg dans 47 cas (32 %) et 15 mm Hg dans 16 cas (11 %). La sensibilité, la spécificité, la valeur prédictive positive, la valeur prédictive négative et l'exactitude de l'examen abdominal clinique permettant d'identifier une PIA élevée se sont établies à 40 %, 94 %, 76 %, 77 % et 77 % respectivement. L'examen abdominal clinique présentait une sensibilité, une spécificité, une valeur prédictive positive, une valeur prédictive négative et une exactitude de 56 %, 87 %, 35 %, 94 % et 84 % respectivement dans un cas de PIA très élevée.

**CONCLUSIONS :** La pression de la vessie était communément élevée dans notre population d'adultes victimes d'un traumatisme critique. Comparativement aux mesures de pression de la vessie, l'évaluation abdominale clinique a montré une sensibilité et une exactitude médiocres dans les cas de PIA élevée. Ces résultats indiquent qu'il faudrait effectuer davantage de mesures routinières de la pression de la vessie chez les patients à risque d'hypertension intra-abdominale.

**A**bdominal compartment syndrome (ACS) is characterized by organ dysfunction resulting from acute and sustained elevation in intra-abdominal pressure (IAP). In recent years, ACS has been recognized most commonly in patients with multiple injuries, severe burns, ruptured abdominal aortic aneurysms, intestinal obstruction and abdominal sepsis.<sup>1-10</sup>

The frequency of raised IAP in critically ill patients is not well known, although recent reports have suggested that intra-abdominal hypertension may be common. Sugure and colleagues<sup>11</sup> reported that 33% of patients who underwent intraperitoneal general surgical procedures had IAPs greater than 20 mm Hg. Morris and colleagues<sup>12</sup> reported a retrospective review of 1175 trauma laparotomies, in which 15% of the 107 patients requiring staged laparotomy manifested ACS. Moore and colleagues<sup>13</sup> reported that ACS developed in 14% of 145 trauma patients in whom the average injury severity score (ISS) was 26.

There is no consensus regarding a clinician's ability to predict IAP, based on abdominal examination. One recent report has suggested that a clinical estimation of IAP is inaccurate in patients in the intensive care

unit.<sup>14</sup> As the manifestations of intra-abdominal hypertension are being increasingly recognized as significant clinical entities in critical care, the accuracy of the clinical evaluation of abdominal pressure requires definition. Therefore, the purpose of this study was to examine the rate of raised IAP and to evaluate the accuracy of clinical abdominal examination versus urinary bladder pressures in the assessment of IAP in critically injured patients. The study was not focused on detecting patients manifesting clinically obvious ACS, who represent the extreme end of the spectrum or the management or outcome of intra-abdominal hypertension.

#### PATIENTS AND METHODS

Adult (older than 15 years) blunt trauma victims who required mechanical ventilation in the critical care unit (CCU) at Sunnybrook and Women's College Health Sciences Centre between Apr. 1, 1996, and June 1, 1997, were eligible for entry into the study. Patients with an anticipated short stay in the CCU (less than 48 hours), a grave prognosis (unlikely to survive longer than 24 hours) or a ruptured bladder were excluded.

Urinary bladder pressures were measured using a pressure transducer attached to the bladder catheter with a sterile 3-way stopcock (Concord Portex, Keene, NH), a modification of the technique of Kron.<sup>15-17</sup> For each bladder pressure measurement, 60 mL of sterile normal saline was instilled into the indwelling catheter. Air in the system was removed to give a continuous column of fluid from the bladder to the transducer. The transducer was zeroed at the level of the symphysis pubis and the mean bladder pressure was recorded. IAP was categorized as normal (10 mm Hg or less) or elevated (more than 10 mm Hg).<sup>2,4,13</sup> Further, elevated bladder pressures (IAP) were classified into 4 grades: grade I (11 to 15 mm Hg), grade II (16 to 25 mm Hg), grade III (26 to 35 mm Hg) and grade IV (more than 35 mm Hg), according to the grading system proposed by Burch and associates<sup>2</sup> and Moore and colleagues.<sup>13</sup> In the context of this study, bladder pressure measurements were not used in making clinical decisions.

Bladder pressure measurements were obtained daily for up to 5 days. Concurrent with each measurement, a clinician (B.R.B., R.F.M. or F.D.B.),

blinded to the urinary bladder pressure measurement, performed a focused physical examination of the abdomen. Based on the abdominal examination, the clinician recorded the intra-abdominal pressure as normal or elevated. The clinical estimation of bladder pressure was based solely on the results of abdominal examination and not on the patient's overall clinical status at the time of examination.

Demographic data, specific injuries, injury severity as measured by the ISS<sup>18</sup> and the need for laparotomy were recorded prospectively. The sensitivity, specificity and accuracy of clinical examination compared with those of bladder pressure measurements in detecting elevated IAP (more than 10 mm Hg and more than 15 mm Hg), were determined. The study protocol, which respected established institutional guidelines for the treatment of patients, was approved by the Centre's Research Ethics Board.

**RESULTS**

Forty-two patients were enrolled in the study. These patients were predominantly male (65%) and the mean (and standard deviation) age was 44 years (20 years). Twenty-five (60%) were involved in some form of motor vehicle collision. This group of trauma patients had multiple severe injuries, with a mean (and SD) ISS of 36 (10). Eleven patients (26%) suffered a pelvic

fracture and 11 (26%) required a laparotomy for intra-abdominal injuries. Five patients (12%) died.

A total of 147 independent abdominal physical examinations were performed on the study group and compared simultaneously with the measured urinary bladder pressure. Most (69%) of the bladder pressure measurements were in the normal range (10 mm Hg or less) (Table I). Twenty-one (50%) of the 42 patients manifested an elevated urinary bladder pressure at some point during the study.

The findings from clinical examination of the abdomen were then compared with the measured bladder pressure (Table II): normal bladder pressure (IAP) was defined as 10 mm Hg or less and an elevated bladder pressure as more than 10 mm Hg. Clinical abdominal examination had a sensitivity of 40%, a specificity of 94%, a positive predictive value of 76%, a negative predictive value of 77% and an accuracy of 77%.

Clinical examination of the abdomen was then compared with the measured bladder pressure with a different threshold for elevation (Table III). As suggested by previous studies, a significantly elevated bladder pressure (IAP) was defined as more than 15 mm Hg. For this threshold, clinical abdominal examination had a sensitivity of 56%, a specificity of 87%, a positive predictive value of 35%, a negative predictive value of 94%, and an accuracy of 84%.

**DISCUSSION**

Increased IAP causes a multitude of detrimental pathophysiological effects that have been well described in experimental and clinical settings. These effects include the following: reduced cardiac output despite apparent high filling pressures,<sup>5,16,19-23</sup> decreased venous return,<sup>16,19,23,24</sup> increased renal and systemic vascular resistance,<sup>5,6,15,16,25</sup> oliguria and renal dysfunction,<sup>5,7,11,15,21,23</sup> impaired respiratory mechanics, including raised peak inspiratory pressures, decreased partial pressure of oxygen in arterial blood, increased partial pressure of carbon dioxide in arterial blood<sup>7,19,22,23,26</sup> and impaired visceral blood flow.<sup>9,20</sup> An important consideration for trauma patients is the fact that these effects are exaggerated by hypovolemia<sup>17,27</sup> and that the addition of positive end-expiratory pressure markedly increases the detrimental effect of increased IAP on cardiac and pulmonary function.<sup>17,19</sup> The full-blown clinical manifestations of this condition are what we know as the ACS, most associated clinically with high ventilatory pressures and a high central venous pressure yet diminished urinary and cardiac outputs.<sup>2,4,7</sup>

Interestingly, adverse effects may also occur with only modest elevations of IAP. For instance, Richardson and Trinkle<sup>19</sup> found that there was a marked decline in cardiac output beginning at 10 mm Hg despite normal arterial pressure, whereas Iberti and

**Table I**

**Urinary Bladder Pressure Measurements (n = 147) in 42 Critically Injured Adults**

Group, bladder pressure, mm Hg	No. (%) of measurements
Normal, ≤ 10	100 (68)
Grade I, 11–15	37 (25)
Grade II, 16–25	7 (5)
Grade III, 26–35	1 (0.7)
Grade IV, > 35	2 (1.4)

**Table II**

**Comparison of the Findings From Clinical Examination of the Abdomen and Measured Bladder Pressure (Elevated Pressure Defined as > 10 mm Hg)**

Clinical examination	Measured bladder pressure	
	> 10 mm Hg	≤ 10 mm Hg
Elevated	19	6
Normal	28	94

**Table III**

**Comparison of the Findings From Clinical Examination of the Abdomen and Measured Bladder Pressure (Elevated Pressure Defined as > 15 mm Hg)**

Clinical examination	Measured bladder pressure	
	> 15 mm Hg	≤ 15 mm Hg
Elevated	9	17
Normal	7	114

associates<sup>16</sup> showed decreased cardiac output with IAPs of 15 mm Hg. Diebel and associates<sup>8</sup> found progressive mesenteric ischemia in pigs subjected to increased IAP, with significant falls in blood flow and mucosal pH at an IAP of 20 mm Hg.

Normal IAP ranges from zero to subatmospheric when measured in millimetres of mercury.<sup>5,28,29</sup> Postoperative IAP has been studied in uncomplicated abdominal surgery and found to be in the range of 3 to 15 mm Hg.<sup>15</sup> Although the effects of raised IAP occur along a continuum, 10 mm Hg has been suggested as the cutoff between normal and abnormal.<sup>4,13</sup> Although abdominal pressures between 10 and 15 mm Hg are elevated and have been classified as grade I ACS, pressures in this range appear to be clinically insignificant.<sup>2,13</sup> As such, in this study we considered an IAP greater than 10 mm Hg as elevated with potential physiological implications but considered an IAP greater than 15 mm Hg to be clinically significant and worthy of specific analysis.

Our patients were severely injured (mean ISS 36). Raised IAP was common in these patients with 32% of all measurements and 50% of all patients exhibiting raised IAP (more than 10 mm Hg). These observations suggest that physicians caring for multiply injured patients should be aware of and consider raised IAP in their overall assessment of such patients. Our study was limited by a small sample size that did not allow us to identify specific clinical conditions that were associated with a raised IAP. The patients were a diverse group with many confounding injuries and premorbid conditions that precluded confidently linking IAP to prognosis and death.

Abdominal physical examination was insensitive for detecting raised IAP: 40% and 56%, respectively, for an IAP more than 10 mm Hg and more than 15 mm Hg. In essence, clinical examination was no better than ran-

dom chance in predicting whether IAP was normal or elevated. Of 47 elevated IAP measurements (more than 10 mm Hg), 28 (60%) had an abdominal pressure estimated as normal by physical examination. These observations are consistent with those reported recently by Castillo and associates.<sup>14</sup> Clinical examination may be unreliable for detecting elevated IAP due to many factors, including abdominal distension from intestinal ileus, visceral and somatic edema, head injury, sedatives, narcotics or neuromuscular blocking drugs.

Intraperitoneal pressure may be accurately determined by measuring gastric, urinary bladder or inferior vena caval pressure.<sup>4</sup> Urinary bladder pressure has been shown to correlate with intra-abdominal pressure for values ranging from 5 to 70 mm Hg in animal models<sup>15,16</sup> and has been recommended as the method of choice for bedside evaluation in the CCU.<sup>4</sup> Iberti and colleagues<sup>17</sup> validated the use of urinary bladder pressure measurement by directly comparing the findings with pressures measured from intraperitoneal drains, and found a very high correlation. The value of routine IAP monitoring in high-risk surgical patients remains uncertain and is not widely practised.<sup>11</sup> Some sources state that routine measurement is not likely to be worthwhile or consistently useful.<sup>12,30</sup> In our experience, though, clinical examination was found to perform poorly in detecting raised IAP. Therefore, if a clinician has the impression of an abnormal or equivocal examination, we would recommend transducing bladder pressures as previously described.<sup>15,17</sup>

In summary, our findings suggest that increased IAP is common in critically injured patients and that physicians should maintain acute awareness of elevated IAP in such patients. Clinical abdominal examination in our patients was an insensitive and inaccurate measure of elevated IAP when

compared with urinary bladder pressure measurements. Based on our observations we recommend that clinicians rely on direct measurement when considering the possibility of raised IAP. We also suggest that the routine measurement of bladder pressures in patients at risk for elevated IAP be considered.

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