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DIRECT MEASUREMENT OF INTRA-ABDOMINAL PRESSURE WITH A SOLID MICROTRANDUCER

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ABSTRACT. Objective. To describe a direct intra-abdominal pressure (IAP) measurement technique using a solid microsensor comparing its values with the ones simultaneously obtained by means of Kron's technique. Comparative study between two different methods to measure intra-abdominal pressure in a multidisciplinary intensive care unit of a university hospital. **Methods.** In 11 critical patients considered irreversibly ill, IAP was simultaneously measured via Kron's technique (IAPK) and by direct measure (IAPC) through an abdominal tap with a Codman microsensor, inserted through it. Several measurements were obtained at different PEEP levels (0, 10 and 20 cm of H20) and bed inclination (0°, 40° and 60°). **Results.** 92 simultaneous measurements of IAPK and IAPC were made. The difference between both measurements (mean ± SD) were: 0.286 ± 0.938 mmHg. The correlation coefficient was r = 0.98. Bland-Altman plot showed a narrow distribution: 95% of the differences were between 1.87 mmHg of each averaged value. No complications with IAPC measurements were found. **Conclusions.** Direct IAP measurement with a Codman microsensor allows continuous monitoring without urinary tract manipulation, is simple to use and to calibrate, minimally invasive and appropriate for patients at risk to develop abdominal compartmental syndrome. Due to its cost it should be reserved for selected critical patients where standard techniques are contraindicated or can be inaccurate.

KEY WORDS. intra-abdominal pressure, pressure monitor, Codman microsensor, abdominal compartment syndrome, intravesical pressure.

INTRODUCTION

Intra-abdominal pressure (IAP) is the pressure measured within the abdominal cavity. Although the abdominal cavity is composed of several compartments such as peritoneal, retroperitoneal, and subperitoneal spaces, it behaves as a unicameral chamber regarding pressure measurements. The normal value of IAP is 2–5 mmHg with variations with respiratory cycle. The importance of IAP is known since Hamernik's 1858 pioneer work [1], however, for more than a century, IAP measurement, intra-abdominal hypertension (IAH) and the abdominal compartment syndrome (ACS) were overlooked [2–5]. It was Kron in 1984, who first described abdominal pressure measurement through the bladder with a simple, easy and low-cost technique [6]. IAP measure has evolved in time, but methodological problems prevented its use to spread widely as routine monitoring in critical care. The gold standard of IAP measurement is its direct measure, through the direct introduction of a catheter or needle into the peritoneal cavity. However, the indirect measure, via Kron's technique [6] or its modified version by Cheatham and Safcsak [7] are currently the most accepted and widespread techniques. In this technique IAP is obtained through the transmission of pressure developed on a partially full bladder, acting as an hydraulic transducer. This technique has shown good correlation with direct measurements in animal models and in human beings [8, 9].

The objectives of this study were: (a) to describe the technique of direct IAP measurement using a solid microsensor (Codman microsensor, usually used for intracranial pressure measurements), and (b) to compare measurements obtained under this technique with the ones simultaneously obtained by means of the classic Kron's technique.

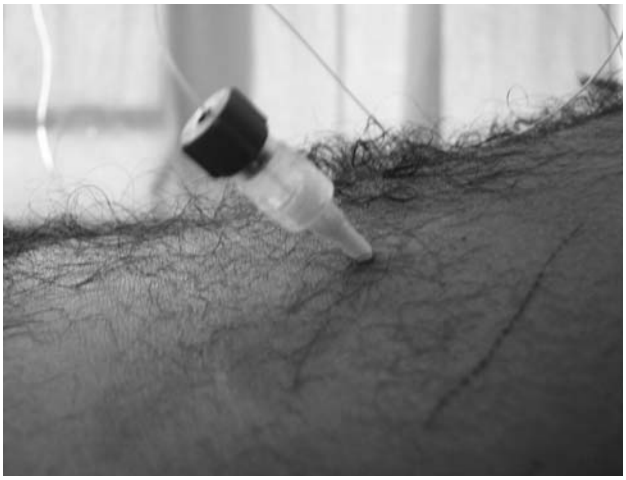

Fig. 1. Microsensor Codman inserted through abdominal wall of a patient.

MATERIALS AND METHODS

Eleven patients admitted to the Intensive Care Unit of the Hospital de Clínicas in Montevideo, Uruguay, during the period from March 2004 to August 2005, were studied. All patients were considered irreversibly ill, without therapeutic possibilities, by the attending medical staff. Family was aware of this condition and consented the study. Two methods of measurement were compared: (1) Kron's technique: IAP was measured by infusing 100 ml of intravesical saline before the measurement. The pubis's spine level was taken as zero level, and the height of the water column above it was the IAP_K. The conversion to mmHg was done by multiplying by 0.736. (2) Direct measurement of IAP was carried out through an abdominal tap with a needle 16 G with a cannula connected to a 5–10 cc syringe. The puncture point was chosen at the intersection between the external margin of the anterior rectus muscle and the line connecting both iliac anterosuperior spines. Two sites of resistance increase were noted during cannula placement: first, the preperitoneal aponeurosis, and then the peritoneal serosa. Once within the peritoneal cavity, smooth aspiration was applied with the syringe. Subsequently the needle was removed, leaving the cannula, and a Codman microsensor, previously zeroed according to the manufacter's protocol, was inserted through it (Figure 1). (Although it was not used in this study, a bedside ultrasonography examination should be practiced in order to guide the correct accomplishment of the procedure.) This measurement constituted the IAP_C, which was also recorded in a real time curve at the display of the monitor with its characteristic respiratory variations. Several measurements were obtained in all patient with both methods simultaneously: using different PEEP levels (0, 10 and 20 cm of H20), and different bed inclination (0°, 40° and 60°). In patients 7 and 11, fewer measurements were recorded. In patient 11, intra-abdominal hypertension was generated by maneuvers of abdominal compression.

Both techniques of monitoring were compared through tests of linear correlation and subsequently building a Bland-Altman plot in order to evaluate the limits of agreement (LOA). Values obtained were considered acceptable if the average difference among the measurements was around 2 mmHg.

RESULTS

Ninety-two simultaneous measurements of IAP_K and IAP_C from 11 patients studied were obtained. The difference between both measurements showed a mean (±SD) of 0.286 ± 0.938 mmHg. The Pearson correlation coefficient between the two measurements was $r = 0.98$ (Figure 2). A Bland-Altman plot was made to further evaluate the LOA. 95% LOA were between 1.87 mmHg of each mean value (Figure 3). No complications of the Codman catheter method were found.

DISCUSSION

IAP monitoring should be routine in patients at risk of developing ACS. Current recommendations indicate that in these patients, IAP should be monitored every 4–6 hours [10]. In this way, IAP values may trigger

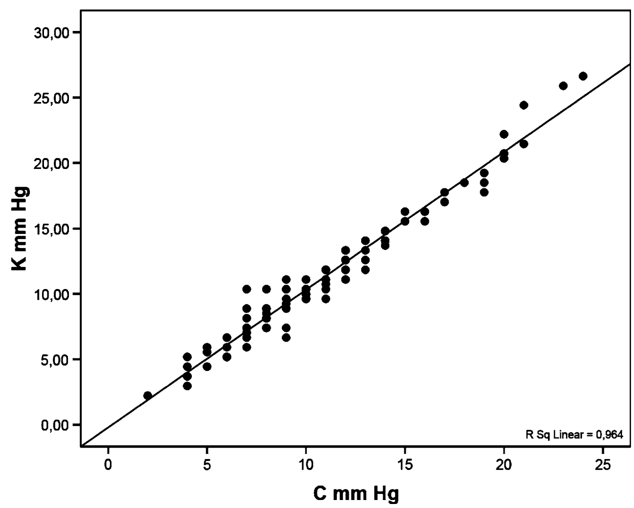

Fig. 2. Linear regression plot showing the relationship between both methods. R = 0.98.

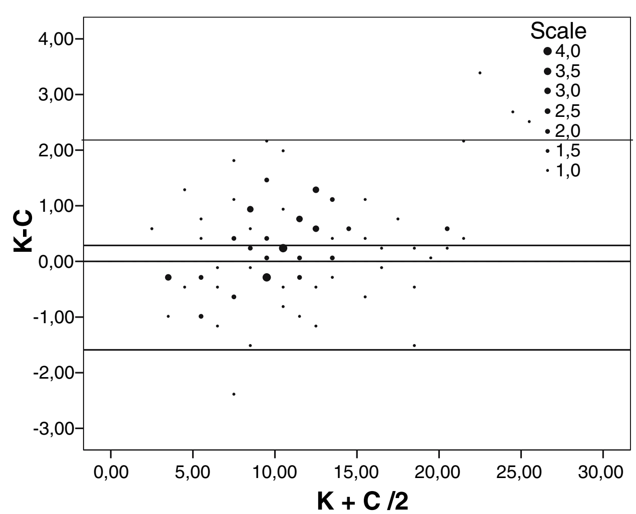

Fig. 3. Bland-Altman plot showing the relationship between both variables average (x axis) and its difference (y axis).95% of the values are between 1.87 mmHg, values that are completely acceptable.

diagnostic studies and medical and/or surgical procedures directed to decompress the abdominal cavity. It has been reported that the trend is more important that a single value [10]. The most common way to measure IAP in intensive care currently is through Kron's, a low-cost, quickly implemented and with few complications procedure. Furthermore, this technique has shown to be accurate in its correlation with the direct measurements [9]. However, this method has several drawbacks: (a) it is a discontinuous measurement and although it can be frequently done, it is impossible to establish an authentic monitoring of this parameter on this basis, (b) it is an indirect technique of measurement and for this reason could distort IAP values in cases where detrusor overactivity is promoted such as intravesical irritation, or vesical compliance reduction of any origin, (c) it requires intravesical catheter manipulation, though the risk of catheter contamination is extremely low with the new "closed" devices. Modifications as established by Cheatham and Safcsak [7] tends to diminish it, but it does not eliminate it totally; (d) there are contraindications for IAP measured through this technique in patients with urinary tract infection or trauma, pelvic trauma, and cistostomy. With these problems in mind, we consider the advantages of IAP measured by applying the technical progress in direct pressure measurement with solid microtranducers. We used Codman's microsensor, a microminiature silicon strain gauge type sensor mounted at one end with an electrical connector at the other end, usually used for intracranial pressure measurements. Our study has shown a good correlation between measurements done with Codman's catheter and through intravesical way via Kron's technique. A small bias to higher pressure registered with Kron's, could be explained by the need to infuse volume during the procedure. It has been pointed out, that this infusion could alter IAP values in some critical patients [11, 12]. IAP measured by Codman technique gave an accurate, instantaneous, continuous and real time measurement. This method is ideal to investigate the dynamic behavior of this parameter and to study the not so well-known relationships with other variables, such as PEEP, plateau pressure and intracranial pressure, usually monitored in critical ill patients. Additional advantages are its minimum manipulation once placed, making it adequate for immunosupressed patients during the post-operatory period of abdominal organ (liver or reno-pancreatic) transplantations. We consider, also, that it could be of choice in patients who need prone ventilation for their respiratory condition. In this special position, the use of this method to measure IAP: (a) facilitates its measurement because the difficulty to find the zero pressure point with the Kron's technique. (b) allows the early detection of abdominal hypertension due to the "non-suspended" abdomen.

The method is also indicated in all patients with Kron's technique contraindication. The principal drawbacks of this technique are: (1) it is more invasive that Kron's technique with a low risk of intra-visceral perforation and monitor placement with blind execution [13]. An ultrasonography guided procedure should eliminate this risk [14]. (2) It is expensive.

In conclusion, Codman sensor, allows continuous monitoring of IAP without urinary tract manipulation, it is simple to use and calibrate, and appropriate for patients with risk to develop ACS. Due to its cost it should be reserved for investigation and in selected critical patients with risk of ACS and where standard techniques are contraindicated or can be inaccurate.

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