Intensive Care Med (1994) 20:588-590

Intensive Care Medicine
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Intra-abdominal pressure measurement using a modified nasogastric tube: description and validation of a new technique

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Received: 13 August 1993/Accepted: 20 December 1993

Abstract. *Objective:* This study assessed the accuracy of an intragastric method of measuring intra-abdominal pressure (IAP).
Design: Prospective sequential study with simultaneous paired measurement of gastric and urinary bladder pressures.
Setting: Operating theatre, University Teaching Hospital.
Patients: 9 patients undergoing laparoscopic cholecystectomy were studied.
Interventions: Intraperitoneal pressures were monitored during peritoneal insufflation at laparoscopy up to a pressure of 20 mmHg.
Measurements and results: Intra-abdominal pressure measurements were recorded simultaneously using a gastric balloon and urinary catheter. Gastric pressure may be up to 4 mmHg higher or 3 mmHg lower than urinary bladder pressure.
Conclusions: Intra-abdominal pressure can be measured easily in this new fashion, allowing a continuous pressure trend to be obtained without interfering with urinary output estimation.

Key words: Intra-abdominal pressure measurement – Gastric tonometry – Laparoscopy

Intra-abdominal pressure measurements is increasingly used in clinical practice as a guide to intra-peritoneal pathology and predictor of renal function [1, 2]. A number of different techniques have been used to measure intra-abdominal pressure. Thorington and Smith measured intra-abdominal pressure trans-rectally in dogs [3]. Bradley used a Miller Abbott tube in the rectum and a Hamilton manometer in the stomach to record pressure [4]. Direct cannulation of the peritoneal cavity and the injection of air have also been used [5]. However it was not until an intravesical method of IAP measurement was developed that the technique has gained widespread acceptance [6]. The technique has been modified slightly by Iberti and colleagues [7]. The intra-vesical technique of IAP monitoring, while reliable, is cumbersome to perform and interferes with the estimation of the patient's urinary output readings. Measurement of IAP using an intragastric balloon attached to a nasogastric tube has potential benefits in terms of ease of use.

The aim of this study is to describe a new method of intra-abdominal pressure measurement using an intra-gastric balloon and validate it with the existing intravesical method.

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Methods

Recordings were performed in 10 patients undegoing laparoscopic cholecystectomy at Liverpool Hospital. The study was approved by the hospital ethics committee and informed consent was obtained from the patients. All patients underwent a general anaesthetic, with muscle relaxation and artificial ventilation. Simultaneous IAP recordings were obtained by means of an intragastric balloon and urinary catheter transduced to a Datex AS3 three channel recorder. All had orogastric insertions of a gastric tonometer with a balloon attached ["Trip" TGS catheter, Tonometric Inc, Bethesda, MD]. The tonometric balloon on the tube is usually employed for tonometry, a technique of indirectly measuring intramural pH [8]. The intragastric position of the tonometer was confirmed by aspiration of gastric juice, auscultation of air insufflation into the stomach, and confirmation of a rise in IAP following external epigastric pressure. None of the patients had intra-abdominal adhesions at laparoscopy. The stomach was visualised at laparoscopy to confirm its intra-abdominal position.

A pressure volume curve of the gastric tonometer balloon at 37 °C confirmed that instillation of up to 3.0 ml of air allowed the balloon to act as a pressure transducer. Each balloon was individually checked prior to insertion. The balloon on the gastric tonometer was completely emptied prior to injection of 2.5 ml of air. Particular attention was paid to make sure that the stomach was in a period of quiescent motor activity with no evidence of the phase 2 or 3 of the migrating motor complex [9].

The patients were placed supine on the operating table. A size 16 Foley catheter was inserted into the bladder. A T piece bladder pressure device was attached to the indwelling catheter and a pressure transducer was connected to the system. The pressure transducer was placed at the same level in the mid axillary line as the transducer from the gastric balloon. Isotonic saline (50 ml) was inserted into the bladder via a three way stopcock. The urinary catheter was clamped. After zeroing the transducer the pressures from both the stomach and bladder were recorded simultaneously with a two chart recorder. Insufflation pressure was limited to 20 mmHg during the experiment. Carbon dioxide was insufflated at a rate of 2 l/min. The tonometer and urinary catheter were removed at the end of the procedure.

Statistical analysis was carried out using SAS version 6.04 (SAS Institute Inc, Cary, NC). The Bland and Altman approach was used to measure the bias and precision of the intragastric method against the intravesical method [10]. Adjustments for age and body mass index were not attempted. Values are reported as mean and standard deviations.

Results

They were 8 females and 1 male in the study. One patient was excluded due to protocol violation as the balloon required of 3.5 ml to allow it to record pressure. The mean age was 43±15 (range 21–72) years. The mean body mass index was 29.6±5 kg m^{-2}. Insufflation of the abdominal cavity was achieved with carbon dioxide to a preset pressure of 20 mmHg as regulated by the insufflator. The mean volume of gas insufflated was 8.8±4.3 l. Baseline pressure were 0–2 mmHg in all patients rising to a mean maximum pressure of 14±4 mmHg, range 8–20 mmHg. There were 185 pairs of simultaneous measurements of intragastric and urinary bladder pressures.

The pressure volume response was variable, due to the different peritoneal capacity of individual patients. The transduced pressures had a rapid response time facilitating recording of changes during insufflation. The mean insufflation time to these pressures was 4.7±1.9 min.

Figure 1 shows a comparison of intra-abdominal pressure readings measured by a urinary catheter and by the gastric tonometer, a new technique. The mean difference was 0.35 mmHg (95% confidence interval 3.8 to −3.1 mmHg). Thus the gastric balloon technique tends to give a reading that was up to 3 mmHg below or 4 mmHg above that of the urinary catheter technique. Despite this, the limits of agreement are small. The difference against the mean for IAP measurement is shown in Fig. 1. This suggests that intra-abdominal pressure can be measured easily using the gastric balloon catheter without interfering with urinary output estimation.

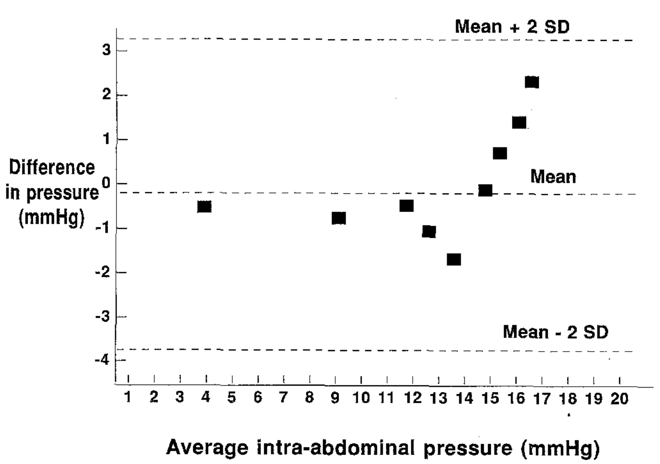

Fig. 1. Bland and Altman plot comparing intra-abdominal pressure measurements using a gastric tonometer and urinary catheter

Discussion

This study demonstrated that intra-gastric pressures are valid measure of IAP during laparoscopic insufflation. The validity of measuring IAP using a transurethral bladder catheter has been shown experimentally [6] and in clinical practice [11]. It is at present the standard method of clinically measuring intra-abdominal pressure. It is not practical to routinely measure IAP by direct cannulation [5] as it is an invasive procedue, with the potential complication of visceral puncture. Direct intra-abdominal pressure measurement was not undertaken in this study as it would have required an open intraperitoneal catheter through a separate incision, before insufflation of gas and as such would have posed ethical difficulties. While it is current clinical practice to measure pressure using the flow of carbon dioxide through the Veress needle, its accuracy has not been documented [12]. Comparison between the two techniques in this study were limited to below 20 mmHg to avoid the risk of cardio-respiratory arrest during laparoscopy at higher pressures. The limits of agreement between gastric pressure measurement and urinary bladder pressure are acceptable within this range.

The transvesical measurement of IAP while reliable, is time consuming and requires instillation of saline into the bladder and clamping of the urinary catheter. There may also be an increased risk of infection with the instillation of solutions through a system of catheters, *T* pieces and stopcocks. In addition this new method allows a continuous recording of IAP over period of time, while the intravesical method requires a discontinuous recording. Intra-abdominal pressure monitoring using tonometry is more expensive ($ 136) compared to the intravesical method ($ 4), and realistically be utilised only when the patient has a tonometer in place for measuring intra-mucosal pH.

Simultaneous pHi and IAP measurements are not possible with the tonometer.

Bradley was one of the first to utilise intra-gastric pressure measurements to measure IAP, using a Hamilton manometer in the stomach and suggested that the abdomen and its contents should be considered as relatively non-compressible and fluid in nature [4]. A potential disadvantage of intragastric recording is the effect of the Migrating Motor Complex. This cyclical motor front in normal subjects can be identified as periods of regular contraction lasting two minutes every 90 min [9], and on a transduced reading is easy to identify.

Reduction in urinary output occurring in patients is related to raised renal parenchymal pressure and raised venous pressure rather than extrinsic pressure on the ureters [13]. In the clinical setting it is important to measure IAP in a manner that is easy to perform. Intragastric pressure monitoring in this study has proven to be a valid method of measuring IAP.

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