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Validation of a novel method for measuring intra-abdominal pressure and gastric residual volume in critically ill patients

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Abstract

Background: Gastric residual volume (GRV) can be measured in a variety of ways in critically ill patients, most often, the nasogastric tube is disconnected and the GRV is aspirated via a 60 mL syringe. Bladder pressure (IBP) measurement is the gold standard for intra-abdominal pressure (IAP) estimation. This study will look at the validation of a novel method combining measurement of GRV and estimation of IAP via intra-gastric pressure (IGP).

Methods: In total 135 paired IAP and 146 paired GRV measurements were performed in 37 mechanically ventilated ICU patients. The IAP was estimated via the bladder (i.e. IBP) using the FoleyManometer and via the stomach (i.e. IGP) with the new device. The GRV was measured with the new device ($GRV_{prototype}$) and via the classic method ($GRV_{classic}$). The devices were provided by Holtech Medical (Charlottenlund, Denmark) and data were retrospectively analysed.

Results: The number of paired measurements in each patient was 4 ± 1. The mean IBP was 10.7 ± 4.1 and mean IGP was 11.6 ± 4.1 mm Hg. Correlation between the IBP and IGP was significant, however moderate ($R^2 = 0.51$). Analysis according to Bland and Altman showed a bias and precision of 0.8 and 2.7 mm Hg respectively, however the limits of agreement (LA) were large and ranged from –4.5 to 6.1 mm Hg. Changes in IGP correlated well with changes in IBP. The median $GRV_{prototype}$ was 80 mL (0–1050) and equal to the median $GRV_{classic}$ of 80 mL (0–1250). Correlation between the 2 methods was excellent ($R^2 = 0.89$). Analysis according to Bland and Altman showed a bias and precision of -0.8 and 52.3 mL respectively and the LA ranged from –103 to 102 mL. Changes in $GRV_{classic}$ correlated well with changes in $GRV_{prototype}$.

Conclusions: The results of this multicentre pilot study show that GRV can be measured with the new device. Furthermore this allows simultaneous screening for intra-abdominal hypertension with IAP estimation via IGP.

Key words: intra-abdominal pressure; gastric residual volume; intra-gastric pressure; Intra-abdominal hypertension; abdominal compartment syndrome; critically ill patients; enteral feeding

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Intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS) are associated with organ dysfunction, mortality, and a number of other poor outcomes among critically ill patients [1, 2]. In the past decade, consensus definitions and treatment guidelines were developed by the World Society of the Abdominal Compartment Syndrome (WSACS) in an attempt to increase awareness of IAH and ACS and standardize their prevention, diagnosis, and management [3, 4]. Updated consensus definitions and clinical practice guidelines were published in 2013 [5].

Diagnosis of IAH requires either direct measurement of intra-abdominal pressure (IAP) via a catheter placed directly into the peritoneal cavity or indirect measurement via intragastric, intrarectal, intrabladder, or inferior vena cava catheters [6]. As clinical examination is an inaccurate predictor of IAH/ACS, direct or indirect measurement of IAP is important in order to establish diagnosis of IAH and prevent evolution to overt ACS [3, 6, 7]. As such, a valid and reliable bedside technique of IAP monitoring is necessary, and, in the 2013 WSACS Clinical Practice Guidelines, intrabladder pressure (IBP) was recommended as the preferred method of indirect IAP measurement in critically ill patients [5].

In this study, we sought to validate a novel method for indirect estimation of IAP, which may be done during measurement of gastric residual volume (GRV), a procedure already commonly performed in many ICU's to assess success of enteral tube feeding. Protocols for GRV monitoring have been introduced into standards of care because high GRV's are related to delayed gastric emptying, which is associated with an increased risk of pulmonary aspiration of gastric contents [8].

METHODS

PATIENT POPULATION

This was a multicentre retrospective cohort study conducted of patients admitted to a surgical ICU of 2 tertiary hospitals (Ziekenhuis Netwerk Antwerpen, ZNA Stuivenberg Hospital, Antwerp, Belgium and Academic Medical Centre (AMC), Amsterdam, The Netherlands) during a 6 month period. Using the electronic ICU patient database, patient demographics, IGP, IBP, GRV were collected. Severity of illness was evaluated using the Simplified Acute Physiology Score (version II; SAPS II) and the Acute Physiology and Chronic Health Evaluation (version II; APACHE II). Patient data was accessed via the database program by one of the study investigators and exported to an Excel worksheet (Microsoft, Redmond, Washington, USA). All data were anonymised before analysis.

ETHICAL CONSIDERATIONS

The study was conducted in accordance with the ICU protocol, the Declaration of Helsinki and applicable regulatory requirements as approved by the institutional review board and the local institutional ethics committee (approval number 4147, March 13th 2013). In view of the nature of the study being purely observational and not demanding a deviation from standard clinical ICU care; informed consent from the patient or the next of kin was waived.

DEFINITIONS

According to the Consensus definitions of the WSACS (www.wsacs.org), IAP is the pressure concealed within the abdominal cavity. Normal IAP is around 5 to 7 mm Hg in healthy individuals and around 10 mm Hg in the critically ill patient [4, 9]. IAH is defined by the sustained or repeated elevation of IAP > 12 mm Hg. The combination of elevated IAP above 20 mm Hg and the associated adverse physiological effects (new onset organ failure), constitutes ACS.

IAP MEASUREMENT TECHNIQUES

The IAP and GRV were measured following several techniques as described below:

FoleyManometer (Holtech Medical, Charlottenlund, Denmark): A urinary drainage tubing fitted with a bio-filter inserted between the Foley catheter and the urine drainage bag. The IAP is estimated by the height of the meniscus of the urine column via the bladder (i.e. IBP) with the zero reference at the level where the midaxillary line crosses the iliac crest. The FoleyManometer is scaled in increments of 0.5 mm Hg (Fig. 1).

GastroPV (Holtech Medical, Charlottenlund, Denmark): A new device, the GastroPV is inserted in between the nasogastric probe and the enteral nutrition feeding pump and tubing. The IAP can be estimated via the stomach (i.e. IGP) with the new device (Fig. 2).

Classic GRV measurement ($GRV_{classic}$). The measurement of GRV is neither standardized nor validated. Gastric volume can be considered high if a single volume exceeds 200 mL [10]. The gold-standard up to now, is measuring the GRV by aspiration via a 60 mL syringe after disconnection of the nasogastric tube ($GRV_{classic}$) (Fig. 3).

New GRV measurement ($GRV_{prototype}$). We used in this study also the GastroPV device to measure the GRV ($GRV_{prototype}$) (Fig. 4).

In addition to the measurement of IAP and GRV a cost-effective analysis was performed based on standard prices for the disposables used (GastroPV at 8.5 EUR, 50 mL syringe at 0.30 EUR, absorbent placemat at 0.15 EUR) and nursing time spent (0.83 EUR/min).

STATISTICAL ANALYSIS

Statistical analysis was done using SPSS software version 17 (SPSS Inc., Chicago, USA). Descriptive statistics are presented as mean ± SD for normally distributed values and

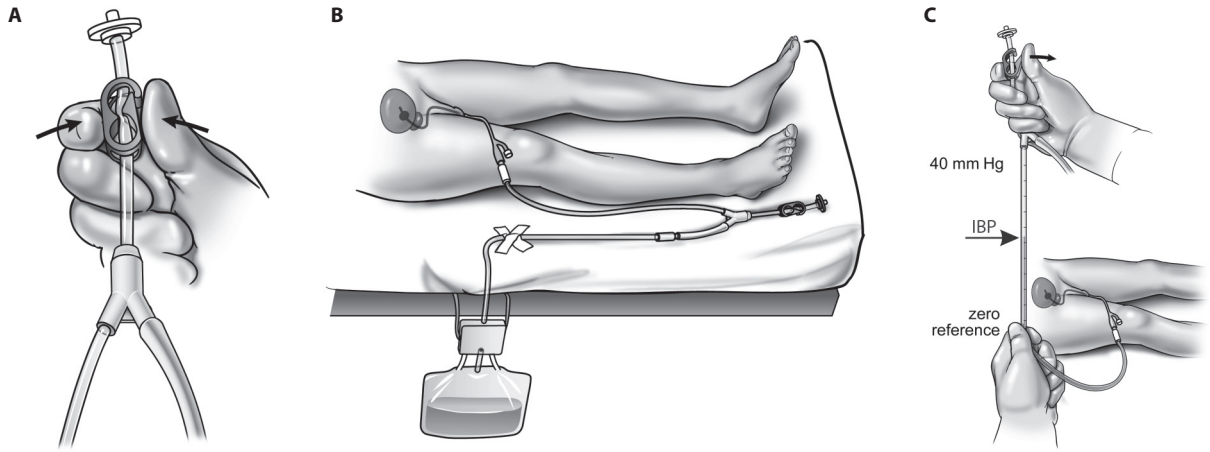

Figure 1. The FoleyManometer

Panel A. Initial set-up
Open the FoleyManometer LV (Holtech Medical, Charlottenlund, Denmark, www.holtech-medical.com) pouch and close the tube clamp
Place the urine collection device under the patient's bladder and tape the drainage tube to the bed sheet
Insert the FoleyManometer between catheter and drainage device
Prime the FoleyManometer with 20 mL of sterile saline through its needle-free injection/sampling port
Prime only once i.e. at initial set-up, or subsequently to remove any air in the manometer tube

Panel B. Urine drainage
Let the urine drain in between IBP measurements
Urine sampling from the needle-free port is facilitated by temporarily opening the red clamp (but remember to close clamp afterwards)
Avoid a U-bend of the large urimeter drainage tube (which will impede urine drainage)
Replace the FoleyManometer whenever the Foley catheter or the urine collection device is replaced, or at least every 7 days

Panel C. Intrabladder pressure monitoring
Place the '0 mm Hg' mark of the manometer tube at the midaxillary line at the level of the iliac crest (mark for future reference) and elevate the filter vertically above the patient
Open the bio-filter clamp, and read IBP (end-expiration value) when the meniscus has stabilized after about 10 seconds
Close clamp after IBP measurement and place the FoleyManometer in its drainage position
This technique uses the patient's own urine as pressure transmitting medium is a surprisingly simple, reliable, and cost-effective clinical tool. Based on a modified version of the IAP monitoring technique described by Kron et al. [3], the disposable FoleyManometer provides a closed sterile circuit that connects between the patient´s Foley catheter and the urine collection device. Each IAP determination takes about 10 seconds, and no subsequent correction of urine output is required. The technique uses a low bladder infusion volume, has a needle-free sampling port and can measure IAP in a range from 0–40 mm Hg. Therefore it is an ideal technique to screen critically ill patients for IAH

as median (IQR) in case of non-normal distribution. Differences between mean values of IAP and GRV were analysed using one-way analysis of variance (univariate analysis). Categorical data were expressed as frequencies and/or percentages and compared using Chi-squared (χ^2) test. Two-sided *P* values of 0.05 or less were considered to indicate statistical significance. We compared the mean values with SD per patient and computed the Pearson correlation coefficients [11]. We also performed Bland and Altman analysis as previously described [12] to analyse the agreement between different methods of IAP measurement and GRV measurement. Two methods are considered equal and may be used interchangeably if R^2 (R — Pearson's correlation coefficient) is > 0.6, if the differences within bias ± 1.96 SD (limits of agreement, LA) are not clinically important, if the precision of the new technique is comparable to the reference technique, and if the percentage error is less than 35%. Finally, the ability of IGP to track changes or trends in IBP was assessed by plotting ΔIBP against ΔIGP during the same time interval (four quadrants trend plot). The concordance correlation coefficient (CCC) is calculated as the percentage of pairs with the same direction of change. Based on clinical relevance, the concordance should be > 90% when pairs with both a ΔIBP and ΔIGP ≤ ± 3 mm Hg are excluded for analysis.

RESULTS

DEMOGRAPHICS

In total, 37 mechanically ventilated ICU patients were included in the study. According to SAPS II type of admission most of the patients were medical (n = 20), followed by emergency surgery (n = 5), burns (n = 5), elective surgery (n = 4) and trauma (n = 3). Table 1 summarizes patient demographics while Table 2 lists respiratory settings and Table 3 haemodynamic parameters.

INTRA-ABDOMINAL PRESSURE MEASUREMENT

In total, 135 paired IAP measurements were performed. The number of measurements in each patient was 4 ± 1. The

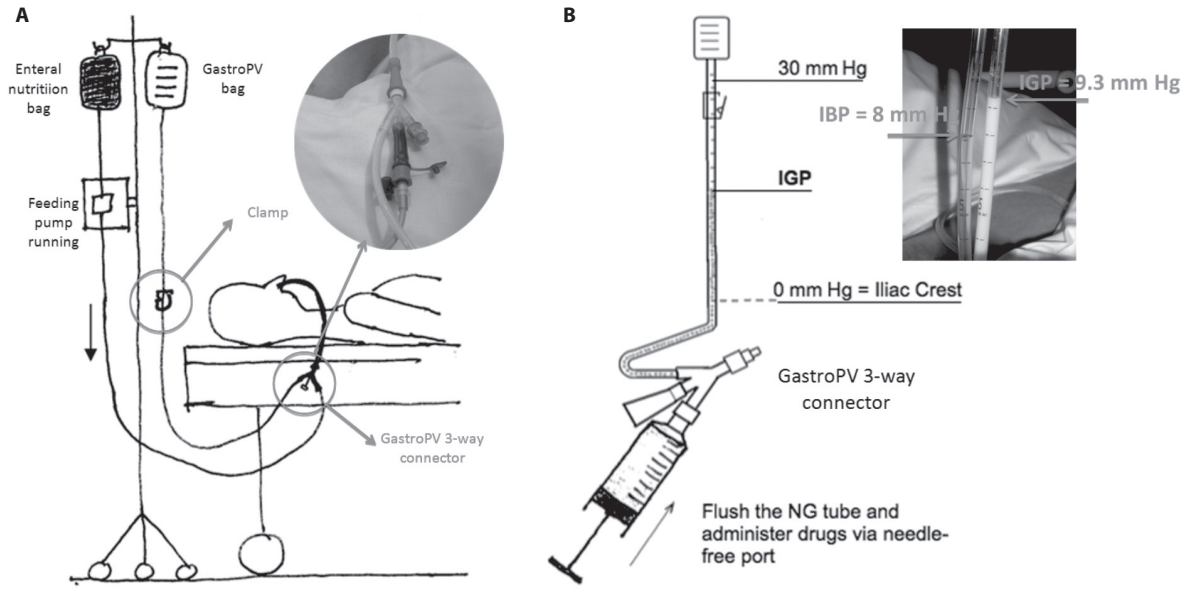

Figure 2. The GastroPV

Panel A. Enteral feeding
Preparations: 1) Stop the feeding pump 2) Insert Gastro PV between the NG tube and the feeding set; 3) Prime the tube with enteral feeding formula; 4) Start the enteral nutrition feeding pump at the desired speed

Panel B. Intragastric pressure measurement
To measure IAP via the GastroPV one must use the following steps: 1) Stop the feeding pump; 2) Place the bag on the bed; 3) Fill a syringe with 25 mL H_2O; 4) Inject 10 mL into the blue port; 5) Unclamp tube, and inject 15 mL; 6) Hold bag in vertical position, with 0 mm Hg at iliac crest; 7) Read IGP, then clamp tube; 8) Re-start feeding pump

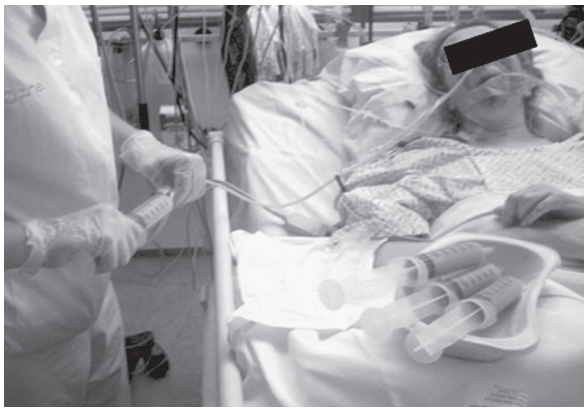

Figure 3. Classic gastric residual volume measurement

The enteral nutrition feeding pump is stopped and the tubing is disconnected. The gastric residual volume (GRV) is aspirated with a 60 mL syringe. Different syringes can be used. The total volume is calculated and the GRV is given back to the patient when < 300 mL (as per ICU protocol)

mean IBP was 10.7 ± 4.1 mm Hg (range 3–25) and mean IGP was 11.6 ± 4.1 mm Hg (range 3–27). Correlation between the IBP and IGP was moderate, with IGP = 1.04 × IBP (R^2 = 0.51, P < 0.001). Correlation improved when only mean values per patient were taken into account, with IGP = 1.044 × IBP (R^2 = 0.63, P < 0.001).

Figure 5 shows the Pearson correlation plot for all paired IAP values (n = 135, Panel A) and for the mean IAP values per patient (n = 34, Panel B). For all measurements, the analysis according to Bland and Altman showed a bias and precision of 0.8 and 2.7 mm Hg respectively (IAP range 3.5 to 26 mm Hg and a coefficient of variation, COVA of 34.3%). However, the LA were large and ranged from –4.7 to 6.3 mm Hg with a percentage error of 49.3% (Fig. 6, Panel A). Examining only mean values per patient, the analysis according to Bland and Altman showed a bias and precision of –0.7 and 2.0 mm Hg respectively (IAP range 6.4 to 20 mm Hg and COVA of 28.9%), with smaller LA ranging from –4.7 to 3.2 mm Hg and a percentage error of 34.9% (Fig. 6, Panel B).

GASTRIC RESIDUAL VOLUME MEASUREMENT

In total, 146 paired GRV measurements were performed. The mean number of measurements in each patient was 4 ± 1. The median $GRV_{prototype}$ was 80 mL (range 0–1050) and median $GRV_{classic}$ was also 80 mL (range 0–1250). Correlation between the 2 methods was excellent with $GVR_{classic}$ = = 1.04 × $GRV_{prototype}$ (R^2 = 0.89, P < 0.001). Correlation improved further when only the mean values per patient were taken into account, with $GVR_{classic}$ = 1.12 × $GRV_{prototype}$ (R^2 = 0.97, P < 0.001). Figure 7 shows the Pearson correlation plot for all paired GRV values (n = 146, Panel A)

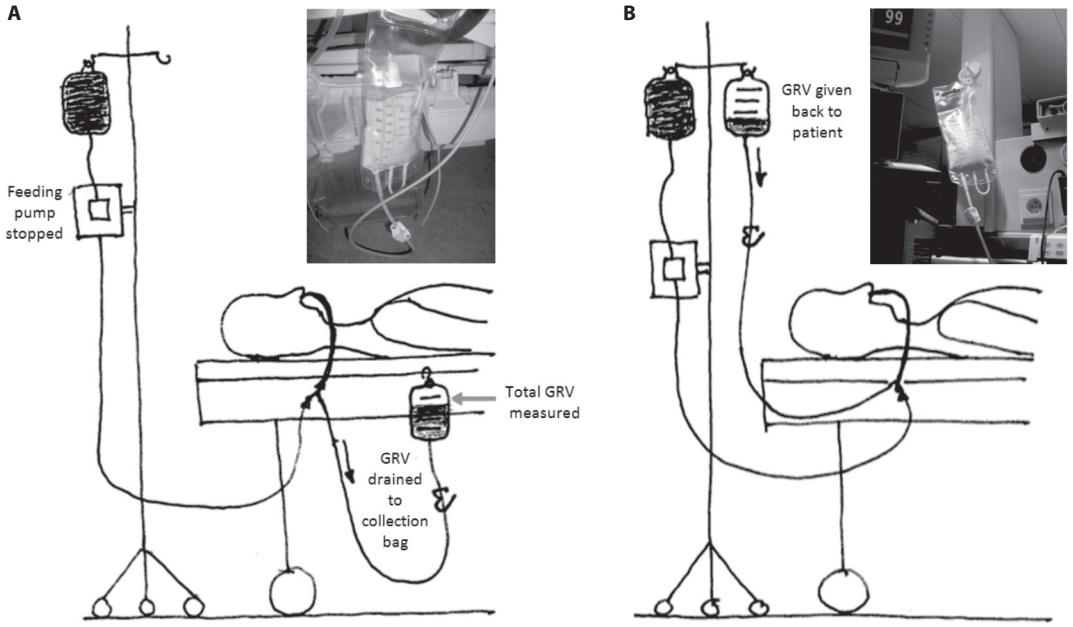

Figure 4. A new gastric residual volume measurement

Panel A. GRV measurement

To measure the Gastric Residual Volume, the feeding pump is stopped, the GRV collection bag is put on the ground or hung at the bedrail and the GRV is drained to the collection bag by gravity. If the bag does not fill spontaneously, or if bubbles appear in the tubing one can gently push the patient's abdomen. Depending on the viscosity, it may take up to 15 minutes for the stomach to empty

Panel B. Giving back GRV to patient

To give back the GRV after measurement, the collection back is hung back and the GRV returns to the patient spontaneously by gravidity

Table 1. Patient demographics at baseline

Variable	Value
Age (years)	62.8 ± 17.4 (range 22–86)
Male to female ratio	4:3
Reason for admission to ICU	Neurosurgery, neurology (n = 9) COPD (n = 5) Burns (n = 5) Miscellanous (n = 5) CABG (n = 3) Acute respiratory failure (n = 3) Cardiac arrest (n = 3) Sepsis and septic shock (n = 2) Abdominal surgery (n = 2)
BMI (kg m^{-2})	26.2 ± 6.3 (16.6–42.9)
APACHE-II score	21.2 ± 4.6 (11–31)
SAPS-II score	50.5 ± 12.2 (17–83)
SOFA score	9.1 ± 3.0 (3–17)
IBP (mm Hg)	10.7 ± 4.1 (3–25)
IGP (mm Hg)	11.6 ± 4.1 (3–27)

COPD — Chronic obstructive pulmonary disease; CABG — Coronary artery bypass graft; BMI — body mass index; APACHE II — Acute Physiology and Chronic Health Evaluation II, SAPS II — Simplified Acute Physiology Score II, SOFA — Sequential Organ Failure Assessment score, IBP — intra-bladder pressure, IGP — intra-gastric pressure

Table 2. Respiratory parameters

Variable	Value
TV (mL)	589 ± 122
TV (mL kg^{-1})	7.9 ± 2.2
RR (min^{-1})	20.1 ± 8.3
Pplat (cm H_2O)	23.9 ± 4.6
PEEP (cm H_2O)	7.4 ± 2.5
FiO_2 (%)	38.3 ± 9.8
SAS	2 ± 0.9
Remifentanyl (n = 23) (μg kg^{-1} min^{-1})	0.14 ± 0.07
Propofol (n = 19) (mg kg^{-1} h^{-1})	2 ± 0.9
Midazolam (n = 13) (mg kg^{-1} h^{-1})	0.2 ± 0.1

TV — tidal volume; RR — respiratory rate; Pplat — plateau alveolar pressure; PEEP — positive end-expiratpory pressure; SAS — sedation and analgesia score

Table 3. Hemodynamic parameters

Variable	
MAP (mm Hg)	79.3 ± 15.5
CVP (mm Hg)	12.2 ± 4.8
Norepinephrine (n = 17) (μg kg^{-1} min^{-1})	0.14 ± 0.16
Dobutamine (n = 9) (μg kg^{-1} min^{-1})	4.5 ± 2.8

MAP — mean arterial pressure; CVP — central venous pressure

and for the mean GRV values per patient (n = 37, Panel B). For all measurements, the analysis according to Bland and Altman showed a bias and precision of –0.8 and

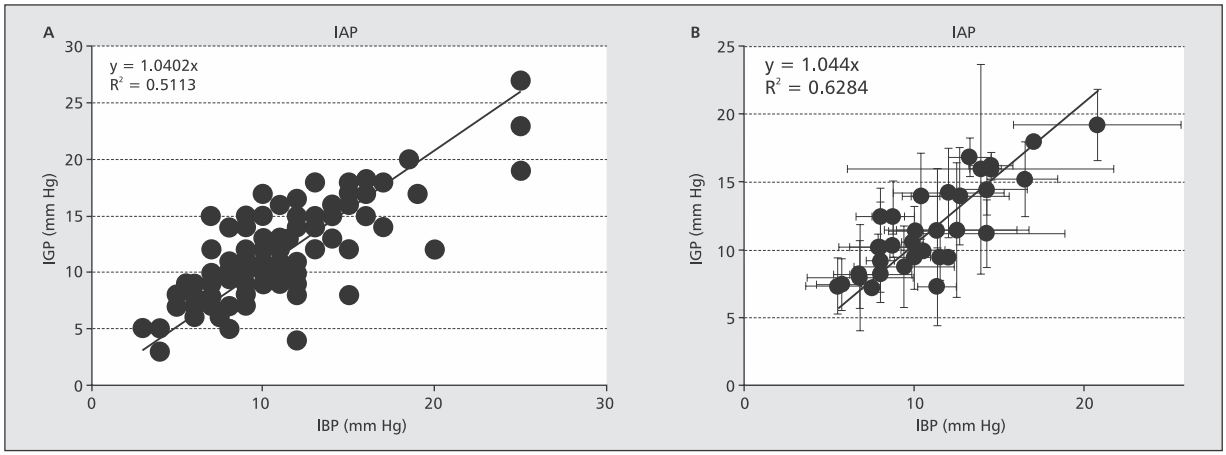

Figure 5. Regression analysis of intrabladder (IBP) and intragastric pressure (IGP)

Panel A. All paired IBP and IGP measurements (n = 135)**; Panel B.** Mean IBP and IGP values per patient (n = 34); dots represent patients averages (n = 34) with mean ± SD of IBP and IGP; IBP — intrabladder pressure; IGP — intragastric pressure

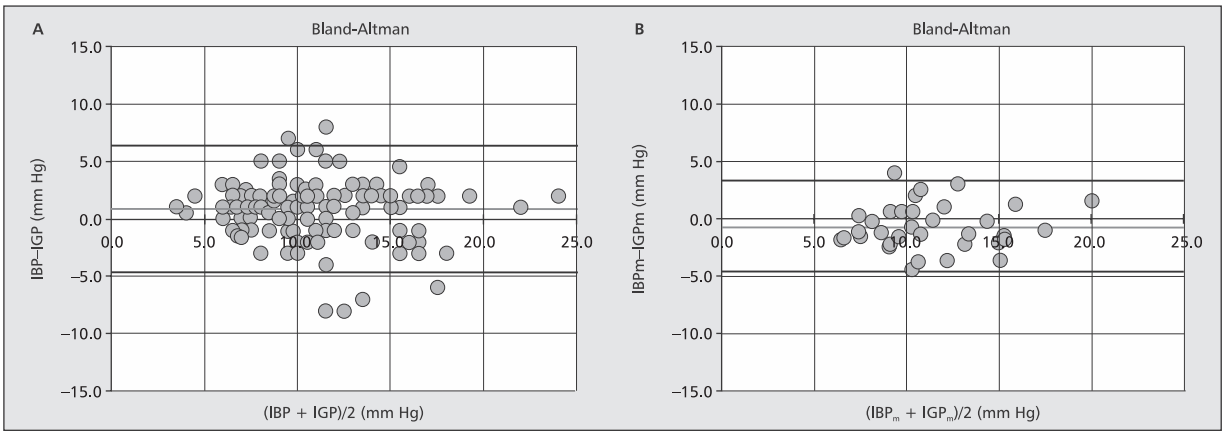

Figure 6. Bland and Altman analysis

Bland-Altman analysis of all paired IBP and IGP measurements (n = 135, Panel A) and of paired measurements of mean IBP (IBPm) and mean IGP (IGPm) values per patient (n = 34, Panel B). Solid lines indicate lower and upper limits of agreement

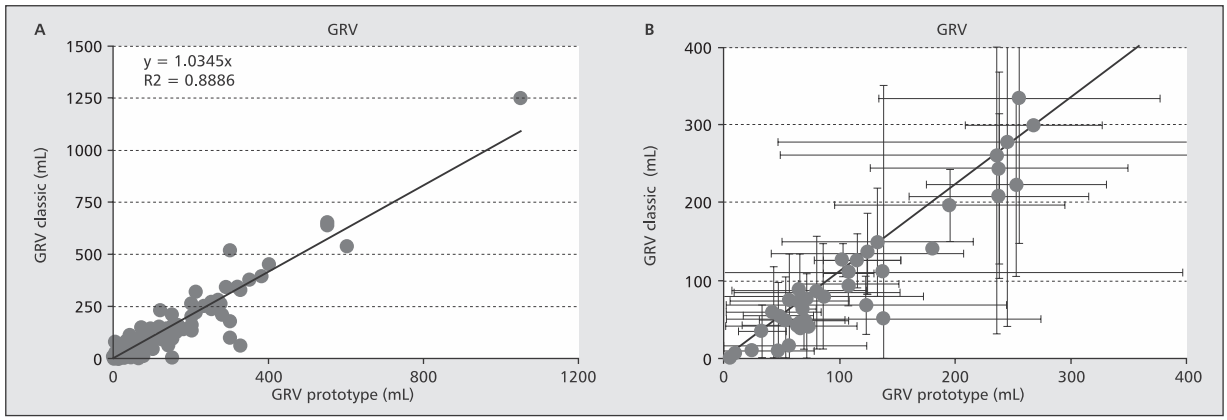

Figure 7. Regression analysis of gastric residual volume measurements with the classic and new method. **Panel A.** All paired GRV measurements (n = 146); **Panel B**. Mean GRV values per patient (n = 37). Dots represent patients averages (n = 37) with mean ± standard deviation of $GRV_{protype}$ and $GRV_{classic}$
GRV: gastric residual volume

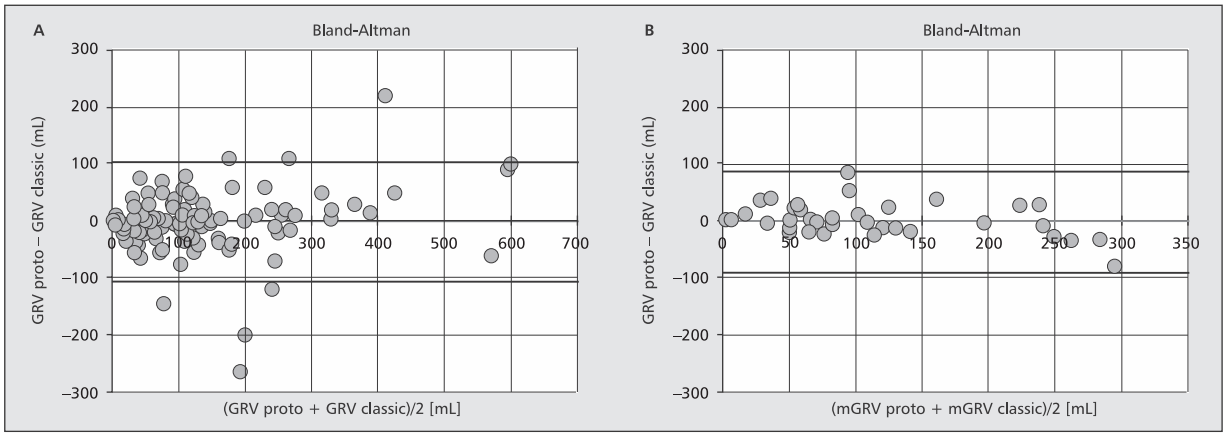

Figure 8. Bland and Altman analysis. Bland-Altman analysis of all paired $GRV_{prototype}$ and $GRV_{classic}$ measurements (n = 146, Panel A) and of paired measurements of mean $GRV_{prototype}$ (m $GRV_{prototype}$) and mean $GRV_{classic}$ (m$GRV_{classic}$) values per patient (n = 37, Panel B)

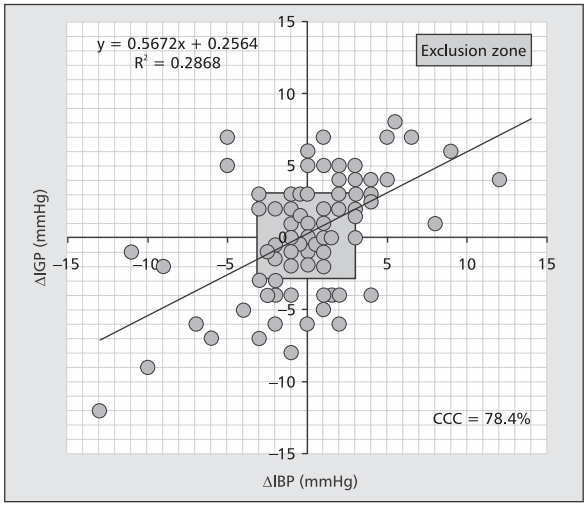

Figure 9. Four quadrants trend plot for changes in IBP (ΔIBP) vs. changes in IGP (ΔIGP)

Plot for 102 paired measurements of ΔIBP and ΔIGP. From the 102 initial paired measurements, 65 pairs were excluded because either ΔIBP or ΔIGP were ≤ ± 3 mm Hg or because ΔIBP or ΔIGP was equal to zero (exclusion zone). The calculated level of concordance was 78.4%. See text for explanation

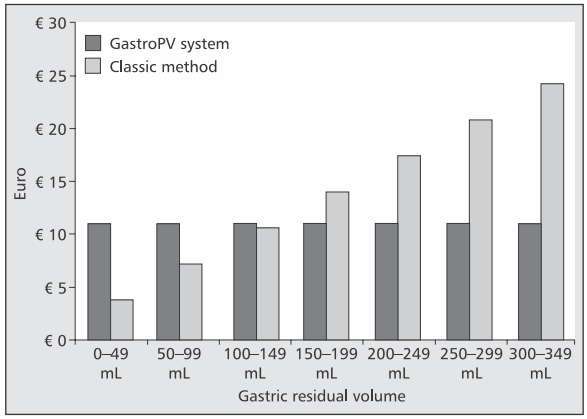

Figure 10. Cost-effectiveness analysis, see text for explanation

52.3 mL respectively (GRV range 0 to 1150 mL and COVA of 120%) and the LA ranged from −106 to 104 mL with a percentage error of 87.1% (Fig. 8, Panel A). Looking at the mean GRV values per patient, the analysis according to Bland and Altman showed a bias and precision of −1.9 and 44.3 mL respectively (GRV range 2.6 to 1150 mL and COVA of 134%), with smaller LA ranging from −91 to 87 mL and a percentage error of 62.8% (Fig. 8, Panel B). The median drainage and return times for the stomach content were 5 min (0.5–15) and 2.5 min (0–21) for $GRV_{prototype}$ compared to 2 min (0.1–10) and 1 min (0–8) for $GRV_{classic}$ ($P < 0.001$ for both comparisons).

COST EFFECTIVENESS ANALYSIS

A preliminary cost effectiveness analysis shows that the price of measuring GRV with the classic method ranges from 3.84 € to 24.18 € per day, depending on the amount of GRV. Price of measuring GRV with the GastroPV system is independent of GRV size and is estimated at 9.49 € per day. The gastro PV system if priced at 8.5 € could become cost effective at GRV of 100 mL and more.

DISCUSSION

IMPORTANCE OF IAP

IAH development during ICU-stay has been reported to be an independent predictor of patient outcome [1]. Already numerous risk factors for the development of IAH and/or ACS have been suggested previously, including abdominal surgery, high-volume fluid resuscitation, ileus, and pulmonary, renal or liver dysfunction [1, 4]. Although many of these are likely to increase risk, only a limited number

are supported by evidence [13, 14]. These independent risk factors predict IAH in a mixed medical-surgical population.

IAH may impair nearly every organ system function. For example, IAH compromises cardiac output by upwards movement of the diaphragm at pressures as low as 10 mm Hg, resulting in cardiac compression and reduced ventricular compliance and contractility [15]. Extrinsic compression of the lung due to elevation of the diaphragm can compromise pulmonary function in mechanically ventilated patients in many ways, causing hypoxemia and hypercapnia [16]. Acute renal failure is also one of the main contributions of ACS, and renal vein compression seems to be the major cause of renal impairment [17]. Renal artery vasoconstriction is more secondary to depression of the cardiac output [18]. In general, oliguria can be noted at an IAP of approximately 15 mm Hg, developing into anuria at an IAP of approximately 30 mm Hg [19]. Very important to mention is the gastrointestinal system as one of the organs most sensitive to elevation of IAP. Causes of dysfunction of the gut include compromised mesenteric blood flow and decreased intestinal mucosal perfusion [20, 21]. This hypoperfusion of the gastrointestinal system leads to loss of mucosal barrier, with consequent bacterial translocation, sepsis and multiple system organ failure [22].

IAP MEASUREMENT

Physical examination has little importance in the detection of IAH and it is a poor predictor of ACS [7, 23]. Imaging with chest radiography to recognize decreased lung volumes, atelectasis or elevated hemi diaphragms, or the use of computed tomography (CT) to detect infiltration differences between the retroperitoneal and peritoneal cavity or extrinsic compression of the inferior vena cava or abdominal distension, are also not helpful in the diagnosis of ACS [24, 25].

There are different methods to monitor IAP. Intraperitoneal continuous IAP monitoring is the gold-standard for the measurement of IAP in experimental studies [26]. Another indirect technique is the continuous IAP monitoring and abdominal perfusion pressure (APP) monitoring via a balloon-tipped catheter placed in the stomach (CiMON, Pulsion Medical Systems, Munich, Germany) [27–29]. IAP can be measured indirectly via the bladder, using the Foley-Manometer or measuring the IGP. Up to now, IBP monitoring is regarded as standard of care for the assessment of IAP in critically ill patients, as long as instillation volumes below 25 mL are used [4, 5]. But this method is discontinuous, and potentially infectious and relies on a physiological bladder function.

IGP represents a practical alternative to IBP in the estimation of IBP for the diagnosis of ACS. There is a strong relationship between IGP and IAP in normal individuals [30]. However, the percentage error of all measurements of IAP was 49.3% and 34.9% for the mean values per patient, thus in critically ill patients, both methods for the estimation of IAP can be used interchangeably keeping in mind the possibility of large data variations and the limitations of monitoring techniques. Furthermore, the low CCC raises questions to the ability to keep track of changes in IAP over time. As shown before by Malbrain et al. [31] in some patients, IAP estimation via nasogastric probe and urinary catheter may differ significantly and this may have clinical implications [31]. This situation can occur due to localized ACS, thus clinicians should be aware of this possibility. In order to identify risk factors and to recommend treatment for localized ACS, further studies of simultaneous intragastric and intrabladder IAP measurements are needed. In this study, when looking at the mean values per patient, the bias was ≤ 1 mm Hg with a precision close to 2 mm Hg, good accuracy, reasonable limits of agreement with acceptable percentage error, but poor concordance.

In a prospective study from Gaidukov et al. [32] two different techniques of IAP measurement were compared in a perioperative setting looking at the influence of IAP on respiratory function. A significant correlation was found between IGP and IBP using respectively a balloon-tipped nasogastric probe (CiMON, Pulsion Medical Systems, Munich, Germany) and the FoleyManometer. The positive results of this study stimulate clinicians to use both methods for the estimation of IAP, keeping in mind the large data variations and limitations of these monitoring techniques in different clinical situations.

The possibility of localized ACS needs to be recognized when significant changes between IGP and IBP are noted [31]. In a prospective study from Cresswell et al. [33] the effect of body position on compartmental IAP was analyzed in a clinical setting. A significant variation in pressure op to 16 mm Hg was noted between the gastric pressure and the bladder pressure. Thus, relying on measurement of one compartmental pressure can lead to significantly elevated pressures in the upper abdomen being missed. Collected data demonstrated also a statistically significant increase in the IBP with head-up positioning to 30° due to hydrostatic weight. Thus a simple change in posture could provide a clinically improvement in the upper IAP and thus may improve organ perfusion. In our study we did not evaluate the effect of body position, but using the combination of the new GastroPV system and the Foley catheter makes it possible to distinguish a localized compartment syndrome.

In this multicentre pilot study, we proved that the new GastroPV system is a practical alternative method to estimate IAP measurements, with the advantage of simultaneously measuring the GRV.

IMPORTANCE OF GRV

High GRVs are a manifestation of intolerance of enteral feeding that can be part of a feeding intolerance syndrome, a condition that is not defined by a single clearcut symptom or value, but in which several symptoms are commonly present, such as vomiting, diarrhea, gastro-intestinal bleeding, presence of entero-cutaneous fistulas, etc. Feeding intolerance should be considered present if at least 20 kcal kg^{-1} day^{-1} via enteral route cannot be reached within 72 hours of the feeding attempt [8].

GRV MEASUREMENTS

GRV is frequently checked in critically ill patients fed by enteral nutrition. There are various enteral feeding protocols and this also means a lack of agreement on the frequency of measuring GRV. There is no sufficient evidence to define precise values for high GRV. GRV could be considered high if a single volume exceeds 200 mL. But there is concern that monitoring of GRV's leads to unnecessary interruptions of use of the feeding tube and subsequent inadequate feeding. In a recently published randomized controlled trial from Reignier et al., patients undergoing mechanical ventilation and early enteral feeding, who did not receive monitoring of GRV, were not at any greater risk of developing ventilator associated pneumonia (VAP) [34]. VAP occurred in 38 of 227 patients (16.7%) in the intervention group and in 35 of 222 patients (15.8%) in the control group. These findings are significant in determining against the major role for the gastro-pulmonary route in the pathogenesis of VAP. As a result of not monitoring GRV, critically ill patients will better been fed. The proportion of patients receiving 100% of their calorie goal was higher in the intervention group [34]. The Gastro PV technique reduces the number of manipulations to measure GRV. So theoretically, this technique may have a potential to reduce VAP.

IAH AND ENTERAL NUTRITION

Enteral nutrition preserves gut integrity by decreasing the likelihood of bacterial translocation, by obtaining the immunological function of the gut and by preserving contractility. Hypocaloric feeding can have a negative impact on clinical outcome and mortality in ICU patients [35]. It is important to start enteral nutrition in time during ICU stay to achieve maximum caloric needs. This can be managed by using feeding protocols and correct techniques to measure gastric residual volume. It is also relevant to measure the IAP during enteral feeding. Feeding intolerance (daily caloric intake less than 500 kcal) can be caused by IAH [36]. On the other hand, studies showed, that there is only a marginal increase in IAP during enteral nutrition, and never in the range of ACS [8]. However it is advisable to stop enteral feeding in case of severe ACS [5].

One of the benefits of enteral nutrition besides improving splanchnic perfusion and bowel contractility comes from avoiding over-resuscitation. Less intestinal edema leads to a decrease in IAP and prevention of mesenteric vein compression. In pathophysiological terms, a drop in IAP causes an increase in abdominal perfusion pressure (APP) (APP = MAP – IAP), avoiding villus hypoxia and atrophy.

BENEFITS AND LIMITATIONS

This is a multicenter study. A positive result of measuring GRV with the new device, is the lower cost and the appreciation of nurses because of a lower working load due to reduction of repeated measurements of GRV, because technically, the gastro PV system is a closed monitoring system.

The first limitation of this multicenter study is the small study population group, with only a few patients developing ACS. Secondly, only few patients were observed with high GRV. And finally, in certain circumstances, there are contraindications for measuring GRV. In case of gastroparesis or gastro-intestinal paralysis due to bowel ischaemia, or evolution to ACS, enteral nutrition should be interrupted for an unknown period of time. Thus, convenient feeding protocols will be necessary to use the Gastro PV technique in an appropriate way.

CONCLUSIONS

The IGP monitoring through a Gastro PV introduces a new technique to measure IAP. Advantages are potentially large:

1. We can compare IAP values from IGP and IBP to study the upper abdominal compartment in particular and to compare with the lower abdominal compartment.
2. The Gastro PV technique reduces the nursing manipulations to measure the GRV and allows more frequent GRV measurements to anticipate possible GRV increases, with a potential to prevent VAP.
3. An easier method to measure GRV reduces the nursing workload and allows more time to be spend on other activities.
4. Measurement of IGP does not carry a potential risk for urinary tract infections.
5. The cost analysis shows the Gastro PV to be cost-effective, in particular for those cases with large amounts of GRV.

Further studies are needed to demonstrate the utility to prevent VAP or to detect upper abdominal compartment syndrome with the Gastro PV.

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