The use of point-of-care ultrasound to guide clinical management in intra-abdominal hypertension

Zouheir Ibrahim Bitar[1], Ossama Sajeh Maadarani[1], Tamer Mohamed Zaalouk[1], Mohammed Jaber Mohsen[1], Ragab Desouky Elshabasy[1], Mahmoud Mostafa Elzoueiry[2]

Abstract

***Introduction*: The World Society for the Abdominal Compartment Syndrome (WSACS) developed a medical management algorithm with a stepwise approach to keep intra-abdominal pressure (IAP) ≤15 mmHg. The role of point-of-care ultrasound (POCUS) as a bedside modality in critical care patients, is not well studied in the intra-abdominal hypertension (IAH) management algorithm.**

***Aim*: To test POCUS in the medical management of patients with IAH.**

***Method*: We conducted a prospective observational study. Those who met the inclusion criteria were assigned to undergo POCUS and small bowel ultrasound as adjuvant tools in their IAH management.**

***Result*: A total of 22 patients met the inclusion criteria and were included in the study. The mean age of the study participants was 65±22.6 years, 61% were men, and the most frequent admission diagnoses were hepatic encephalopathy and massive ascites (5 cases). Ultrasound and abdominal X-rays were comparable in confirming nasogastric tube (NGT)'s correct position, but the ultrasound was superior in determining the gastric content (fluid vs solid) and diagnoses of gastric paresis in 2 cases. Small bowel obstruction was present in four patients and confirmed with computerized tomography (CT) abdomen, and 2 of the patients underwent surgical intervention for mesenteric vessel occlusion and transmesenteric internal hernia. Enema treatment was found to empty the bowel incompletely in 72%, 56%, and 42% of the times on days 1, 2, and 3. Four patients with cirrhosis admitted with upper gastrointestinal bleeding and hepatic encephalopathy (out of a total of 8) were found to have large amounts of ascites and ultrasound (US)-guided paracentesis performed.**

***Conclusion*: POCUS can be used in the nonoperative management of IAH. It is an important tool in the diagnosis and treatment of patients with IAH.**

Introduction

Intra-abdominal hypertension (IAH) is a well-documented cause of morbidity and mortality in the critically ill and can affect almost every organ system. (1) The diagnosis and management of IAH the importance of comprehensive strategies to reduce intra-abdominal pressure (IAP) has been recognized. Starting from awareness of the risk factors that predict the development of IAH, the appropriate measurement of IAP, and the current resuscitation options for managing this highly morbid syndrome. The World Society for the Abdominal Compartment Syndrome (WSACS) developed a medical management algorithm with a stepwise approach according to the evolution of the intra-abdominal pressure and aiming to keep IAP≤15 mmHg. (2) Point-of-care ultrasound (POCUS) as a bedside modality in critical care patients could be used as an adjuvant point-of-care tool during IAH management.

[1] Critical Care Unit, Ahmadi Hospital, Kuwait Oil Company
[2] Internal Medicine Department, Ahmadi Hospital, Kuwait Oil Company

Address for correspondence:
Zouheir Ibrahim Bitar, FRCP, EDIC
Critical Care Unit, Ahmadi Hospital, Kuwait Oil Company
PO BOx 46468, Postal Code 64015, Fahaheel, Kuwait
Tel: 0096597223955
Email: zbitar@kockw.com

Methods

Study population

This was a prospective observational study. All patients admitted between the 1st of May 2019 till the end of December 2019, with recognized risk factors for IAH/abdominal compartment syndrome (ACS) were enrolled and treated according to the 2013 WSACS guidelines. (2) The study protocol was approved by the Ethical Committee of the Ahmadi Hospital, informed consent was obtained from every patient or from his or her next of kin.

All patients had IAP were routinely measured in the supine position by urinary bladder pressure after instilling 25 cc 0.9% normal saline solution (NSS) using preassembled kit devices (AbViser urinary catheter). To record IAP, we allowed the system to equilibrate and then noted the pressure reading on the monitor at the end of expiration. The IAP reading lasted for 1-3 minutes, and the valve would then automatically opened and the pressure reading would decrease to zero. Patients were excluded from analysis if any of the following occurred: death within 72 hours, extubation or discharge from intensive care unit (ICU) within 72 hours from ICU admission, or initial normal IAP (<12 mmHg). Demographic data, initial vital signs, admission IAP, admission abdominal perfusion pressure (APP), and clinical data were recorded for each patient. The inclusion criteria were: 1) ICU patients/minimum ICU stay for 3 days, 2) 18 years of age or older, 3) Intubated and mechanically ventilated with adequate sedation (Richmond Agitation-Sedation Scale [RASS]-4 or -5), 4) Able to lie in a supine position for all measurements, and 5)Not exhibiting abdominal respiratory muscle activity.

A trained intensivist performed POCUS for three consecutive days after admission (**Figure 1**):

1. When the evacuation of intraluminal contents was indicated.
   1.1. Ultrasound was used to confirm nasogastric tube (NGT) position and compared with X-ray imaging for patients requiring an NGT for intra-abdominal decompression (WSACS algorithm step 1).
   1.2. Stomach and bowel ultrasound (US) was performed daily to evaluate hollow viscous content and fluid-filled small bowel loops, dilated to >2.5-3 cm (**Figure 2**). There may also be increased intestinal contents (fluid and echogenic material within the lumen of the bowel) (**Figure 3**) or increased peristalsis of the dilated segment, as evidenced by the to-and-fro or whirling motion of the bowel contents (WSACS algorithm step 2), and/or colonoscopy decompression (WSACS algorithm step 3).
2. When the evacuation of intra-abdominal content was indicated.
   2.1. Abdominal POCUS was performed daily either to evaluate the presence of abdominal free fluid or to help percutaneous drainage (WSACS algorithm step 2).

POCUS method

Daily POCUS was performed in all patients to evaluate the stomach and bowel contents (**Figure 1**).

Confirming position of NGT, we used a 4-point ultrasonography protocol: 1) Ultrasound from either the right or left side of the patient's neck to visualize the esophagus, 2) Ultrasound of epigastrium to confirm the passage through the esophagogastric junction, 3) Confirm the positioning in the antrum, and 4) Sonography of the fundus. Finally, gastric placement of the nasogastric feeding tube was confirmed with thorax radiograph. (3)

For stomach views and patients requiring NGT, images were obtained in 2D-mode with the transducer positioned at the level of the epigastrium and left hypochondrium. The convex transducer was placed in a transverse plane, resulting in visualization of the antrum and body of the stomach. At this moment, the insertion of the NGT was commenced, and the stomach content was observed. Once the NGT was visible in the hollow viscous, a 100 ml flush of agitated saline was delivered to confirm the correct positioning.

For small and large bowel visualization, the transducer was placed at the periumbilical level and on both medium-low abdominal quadrants to observe both the right and left colon.

To screen for intra-abdominal free fluid, the POCUS landmarks were on the right upper quadrant, left upper quadrant, and hypogastrium (**Figure 1**), either with a longitudinal or transverse probe position. The various probe positions to enable the different POCUS windows are shown in **Figure 1**. Paracentesis was performed via the insertion of a sterile percutaneous size 6 French pigtail tube with real-time direct ultrasound guidance.

Statistical analysis

The two-tailed statistical tests were performed by the Statistical Package for the Social Sciences (IBM SPSS 19). Student's t-test was used to assess the continuous variables in the case of a normal distribution and the Mann-Whitney test was used for non-normally distributed variables. Fisher's ex-

act test was used for categorical data. All p values were two-tailed, and $p<0.05$ was considered statistically significant. A descriptive statistical analysis was performed to summarize patient characteristics and study measurements.

Results

A total of 43 patients were included in the study. Twenty-one patients were excluded due to one or more of the following reasons: death, extubating or discharge from ICU before the third day of admission, or normal IAP.

The mean age of the study participants was 65±22.6 years old, and 60% were men with one or more associated comorbidities such as hypertension, diabetes, or dyslipidemia. The most frequent cause of IAH was ileus secondary to sepsis and hepatic encephalopathy with massive ascites (**Table 1**). **Table 2** shows the data from the first three consecutive ICU days.

Laparotomy for elevated IAP was not necessary for any of the patients due to full recovery after clinical management.

The mean IAP on admission was 17±15.5 mmHg. Two patients required surgery for mesenteric vessel occlusion and small bowel obstruction suspected by ultrasound small bowel.

All patients required an NGT for the first 24 hours following admission as confirmed by ultrasound of the stomach and agitated saline. Ultrasound was comparable with abdominal X-ray but superior in determining gastric contents (fluid vs solid) and confirming gastroparesis. Furthermore, POCUS allowed a bedside determination of correct NGT positioning into the stomach (antrum) without exposure to radiation. There was 100% accuracy when using the US to determine NGT placement and positioning, with no false negative or false positive observed.

The second step in the WSACS guidelines addresses intraluminal evacuation through the administration of enemas. This strategy was followed in all patients in whom the IAP remained high (above 20 mmHg) on the second measurement (6 hours after admission). The US proved useful in many ways: the first, POCUS allowed assessment of bowel activity (movements) and detection of pathological movement, e.g., to-and-fro (detected in 6 patients, 2 of whom underwent operation); second, it allowed the identification of large bowel contents (right and left colon); third, it allowed measurement of the diameter of the small bowel, which normally should be less than 3 cm, and small bowel obstruction was suspected when the small bowel measured more than 3.0 cm over a length of more than 10 cm and contained increased content; and fourth, POCUS allowed the identification of patients who might benefit from continued enema treatment to lower IAP.

These aspects were considered important, as most patients were medical. For example, small bowel obstruction was present on 2 patients and confirmed with CT abdominal mesenteric vessel occlusion and operated upon. Enema treatment was found to empty the bowel incompletely in 72%, 56%, and 42% of instances on days 1, 2, and 3, respectively. Colonoscopy decompression was not needed in any of our patients.

During the second stage of the WSACS medical management algorithm, the US was a useful adjuvant tool for diagnosing moderate-to-large amounts of free intra-abdominal fluid. Special attention was given to cirrhotic patients who were admitted with upper gastrointestinal bleeding.

Four patients in this group (out of a total of 8) were found to have large amounts of ascites, and US-guided paracentesis was performed (**Figure 2**). The average amount of ascites removed was 3400±1.6 ml, and removal resulted in a significant decrease in the IAP average from 18±4.1 mmHg to 13±2.0 mmHg in all four patients.

Discussion

Intra-abdominal pressure should be measured regularly in critically ill patients, every 4 to 6 hours according to the guidelines for high-risk patients. (2) An early IAH diagnosis can lead to a shorter ICU stay, shorter ventilation, lower incidence of ventilator-associated pneumonia, and higher survival in IAH/ACS. (4,5)

The medical management for IAH and ACS, in the updated 2013 WACS guidelines, is divided into 5 categories: 1) evacuation of intraluminal contents, 2) evacuation of intraluminal occupying lesions or extraluminal (intraabdominal) contents, 3) improvement of abdominal wall compliance, 4) optimization of fluid administration, and 5) optimization of systemic and regional perfusion.

POCUS is widely used in the field of critical care medicine, (6) and bowel ultrasound is getting the upper hand in reaching diagnosis rapidly in abdominal emergencies. Bedside US, performed by an intensivist, had good diagnostic accuracy in small bowel obstruction. (7,8) We had four patients with small bowel obstruction, and two of them were managed surgically. Adding bowel and abdominal ultrasound at the start of the algorithm in managing patients admitted to the medical ICU with IAH will decrease the incidence of missing surgical abdomen presenting with IAH. A fluid-

filled small bowel lumen >2.5 cm is consistent with the diagnosis of small bowel obstruction (SBO). (9) The presence of dilated small bowel loops (>25 mm in the jejunum or >15 mm in the ileum) was the most sensitive (94%) and specific (94%) sonographic finding for SBO in the hands of emergency physicians. (9) Other signs that should be screened for are increased intestinal contents (fluid and echogenic material within the lumen of the bowel) and increased peristalsis of the dilated segment, as evidenced by the to-and-fro or whirling motion of the bowel contents. (10) Visualization of small and large bowel obstruction with ultrasound is as good as computed tomography and superior to plain X-rays, but computed tomography is superior to ultrasound in terms of the etiologic definition for both small bowel obstruction and large bowel obstruction. (11)

We also focused on the first two stages of the WSACS algorithm and applied ultrasound for specific interventions at each stage (escalating from 1 to 4). We used POCUS as an adjuvant tool for IAH management and focused our efforts on steps 1 to 3 of stage one ("evacuate intraluminal content") and steps 1 and 2 of stage two ("evacuate intraluminal occupying lesions or extraluminal content").

Decompression of intraluminal content is recommended in patients with grade I IAP, starting with the insertion of NGT. The NGT was passed under direct US guidance with the probe on the epigastrium, allowing for direct visualization of the tip of the NGT as it was directed to its ideal position close to the pylorus and confirmed with 100 ml agitated saline with 10 ml air (**Figure 2**). A 100% accuracy was observed when using the US to determine NGT placement and positioning. POCUS was used to assess gastric contents after using the prokinetics and on the third ICU day or before removing the NGT.

In the first 2 steps of the second stage of the WSACS medical management algorithm, ultrasound identified moderate-to-large amounts of free intra-abdominal fluid in cases of cirrhotic patients with ascites requiring ultrasound-guided paracentesis and drug-induced hemoperitoneum, and it was also useful in patients with severe acute pancreatitis. All enrolled patients demonstrated reductions in IAP and subsequently better clinical performance during their first three days of admission.

The small number of patients, the observational design of the study, and the fact that this work was a single-center study were the main limitations of the study.

Conclusion

POCUS can be used in the non-operative management of IAH and ACS. It is an important tool in the diagnosis and treatment of patients with IAH.

Disclaimers

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Contribution

ZIB wrote the article, OSM shared in the discussion, and with MJM, RDE, and TMZ shared in collecting the data and revision of the manuscript.

Table 1. Patients characteristics, clinical data, and cause of IAH

Participant characteristics	
- Mean age (years), mean (range)	65 (39-71)
- Gender (male), n (%)	13 (60%)
- BMI (kg/m^2)	27
Clinical data	
- Mean SBP (mmHg), mean (range)	108.5 (83-134)
- Mean HR (beats/min), mean (range)	94 (60-128)
- IMV, n (%)	22 (100%)
- Mean admission IAP (mmHg), mean (range)	18 (12-34)
- Mean admission APP (mmHg)	85
- Vasopressor use, n (%)	18 (80%)
Diagnosis of IAH	
- Bowell obstruction, n (%)	3 (13%)
- Mesenteric vessel occlusion, n (%)	1 (4%)
- Gastrointestinal bleeding, n (%)	3 (13%)
- Clostridium colitis, n (%)	2 (9%)
- Ascites-liver cirrhosis, n (%)	4 (18%)
- Pancreatitis, n (%)	2 (9%)
- Ileus secondary to sepsis, n (%)	6 (27%)
- Drug-induced hemoperitoneum, n (%)	1 (4%)

Legend: IAH=intra-abdominal hypertension; BMI=body mass index; SBP=systolic blood pressure; HR=heart rate; IMV=invasive mechanical ventilation; IAP=intra-abdominal pressure; APP=abdominal perfusion pressure.

Table 2. Data from three consecutive days on IAH treatment

	Day 1	Day 2	Day 3
Mean IAP (mmHg), mean (range)	17 (12-22)	14.6 (10-20)	13 (8-20)
Mean APP (mmHg)	85.5	91.5	107
Mean SBP (mmHg), mean (range)	108.5 (83-134)	109 (90-128)	122 (101-143)
Renal replacement therapy, n	6	4	4
NGT need, n	22	19	16
US gastric content observed, n	22	22	22
Positive bowel content (before enema) viewed on US, n	22	22	22
Positive bowel content (after enema) viewed on US, n	16	10	6
Bowel movements observed in the US, n	10	12	16
Bowel diameter >3 cm, n	14	8	6
Abnormal bowel content movement, n	6	4	3
Number of patients with free abdominal fluid seen on US, n	8	2	2
Positive moderate to a large amount of free abdominal fluid seen on US, n	6	0	0
US-guided paracentesis, n	4	0	0
Operation, n	2	0	0

Legend: IAH=intra-abdominal hypertension; IAP=intra-abdominal pressure; APP=abdominal perfusion pressure; SBP=systolic blood pressure; NGT=nasogastric tube; US=ultrasound.

Figure1. Ultrasound scan of the abdomen in intra-abdominal hypertension

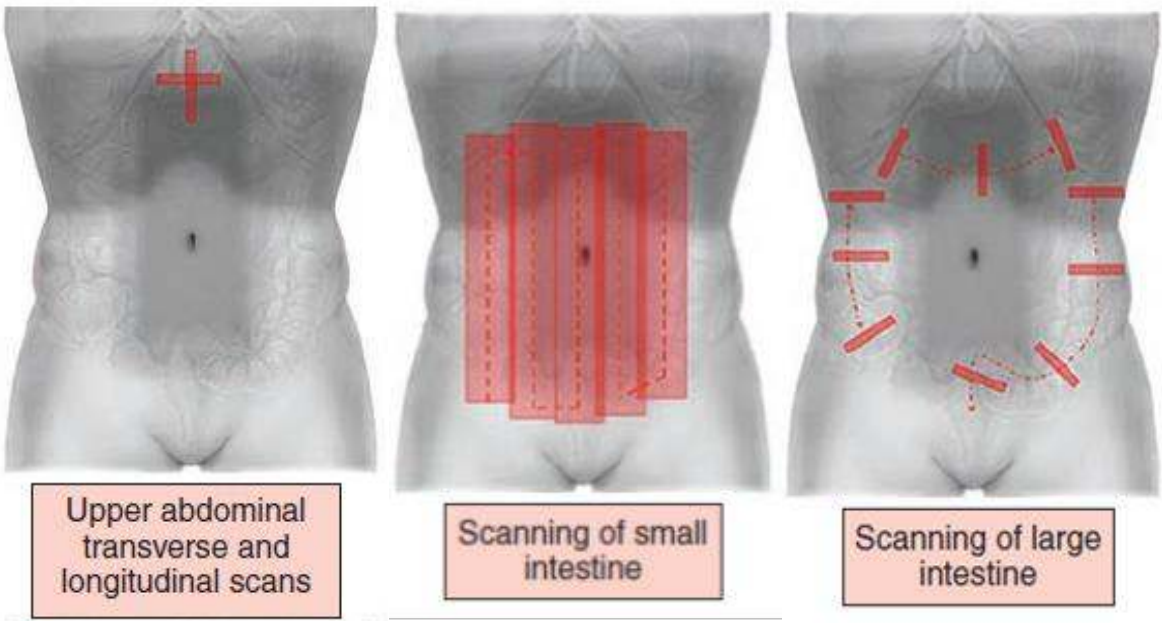
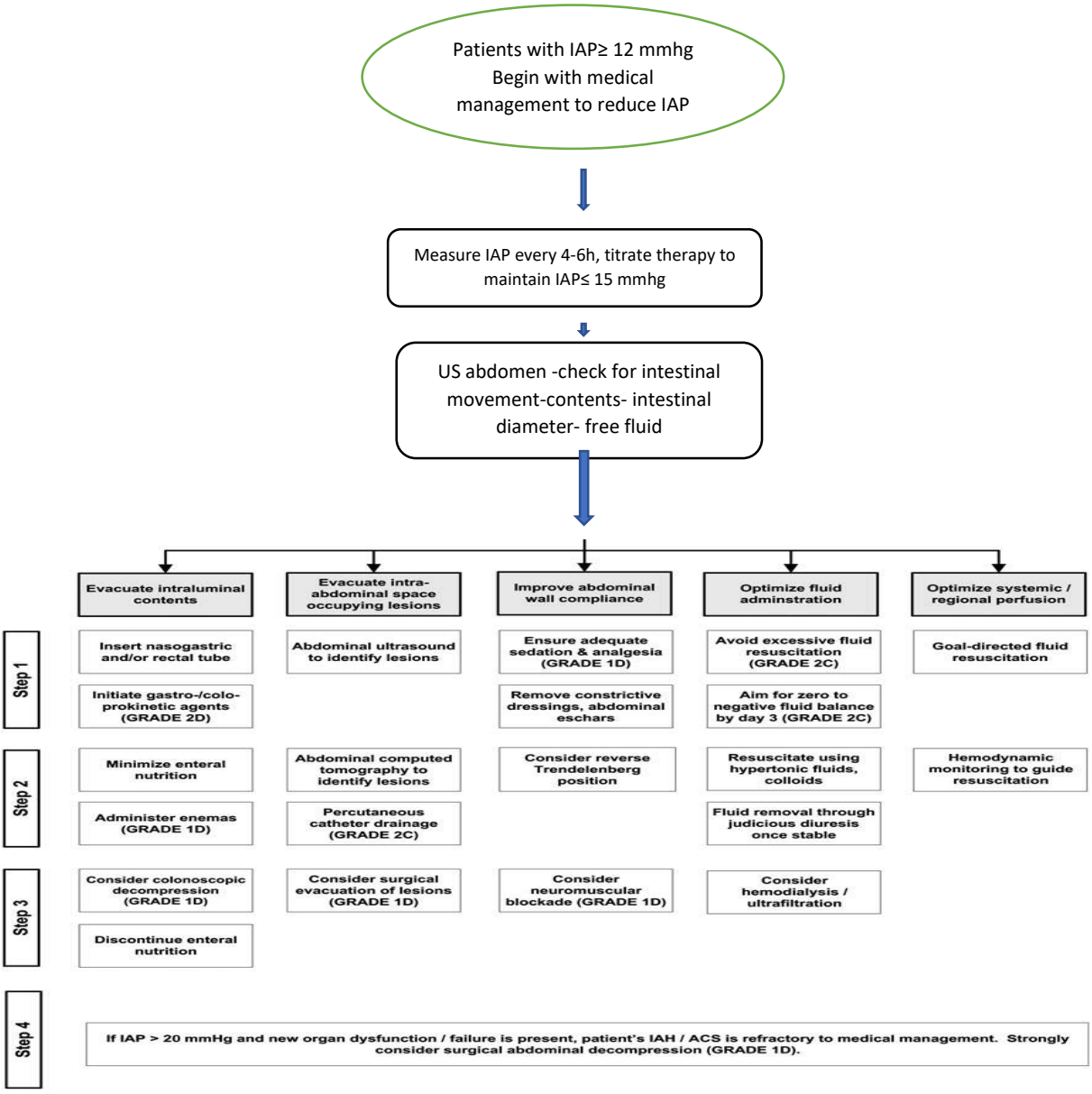


Figure2. Modified WSACS IAH/ACS medical management algorithm with the role of POCUS. Added abdominal ultrasound box



Ultrasound bowel

evaluating for intestinal obstruction. Fluid filled small bowel loops, dilated to > 2.5-3cm.
There may also be increased intestinal contents (fluid and echogenic material within the lumen of the bowel), or increased peristalsis of the dilated segment, as evidenced by the to-and-fro, or whirling motion of the bowel contents

Legend: WSACS=World Society for the Abdominal Compartment Syndrome; IAH=intra-abdominal hypertension; ACS=abdominal compartment syndrome; POCUS=point-of-care ultrasound; IAP=intra-abdominal pressure; US=ultrasound.

Figure 3. Central abdominal ultrasound showing abdominal free fluid (arrow) with small bowel (SB)

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