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Bedside Ultrasound Scan in the Intensive Care Unit of a Referral Hospital in Kigali, Rwanda: Case reports and a review of the literature—Case Series

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ABSTRACT

A bedside ultrasound scan has become an integral part of care in the intensive care unit (ICU). Its advantages include rapid diagnosis and thus management of life-threatening conditions, reduction in the cost of care, and reduced need for transport of patients out of the unit. These advantages have made bedside ultrasound scans one of the best tools in the hands of the critical care physician.

In this case series, we present four patients with different clinical states which include confirmation of central line placement, confirmation of pneumothorax and diagnosis of hemoperitoneum. The management of these patients was positively influenced by using bedside ultrasound scans in the intensive care unit.
Bedside ultrasound in the management of critically ill patients is quick, reliable, and has the potential to influence patient outcomes positively. It is cost-effective, and safe to use for all categories of ICU patients. Deployment of this simple but effective tool is a step in the right direction in the quest to improve patient care in the ICU.

Keywords (MeSH): Bedside Ultrasound Scan, ICU, Case reports, Pneumothorax, Hemoperitoneum

BACKGROUND

Bedside ultrasound scan (USS) has become an integral part in the care of critically ill patients in the intensive care unit [1]. The advantages of Bedside USS include the fact that it is easy to use and fast diagnostic power which allows quick management of life-threatening conditions. In addition, it is inexpensive, and does not require transport of patients out of the unit [2]. These advantages have made ultrasound scans one of the best tools in the hands of the critical care physician.

About three years ago, a large multi-center study involving three different countries in Europe reported the use bedside USS in about 36% of patients daily. About 97% of them were for diagnostic purposes and only 3% were for interventional purposes [3]. Many clinical scenarios have been managed successfully in the intensive care unit with the use of ultrasound scans. Some of these situations include the placement of central venous catheters, diagnosis and confirmation of pneumothorax and other lung pathologies, and the diagnosis of haemoperitoneum [4-6].
As with all other diagnostic or interventional tools, bedside ultrasound scan is not without limitations. These include its operator-dependency, its high cost of initial purchase, and the continued maintenance cost, all of which provide challenges in a resource-challenged environment. In addition, there is a lack of documented evidence to prove its effect on improving patients' outcome [7]. This may be due to the fact that despite the use of Beside USS, some of the patients may still die. Despite these limitations, bedside ultrasound scans remain an auspicious and helpful tool in intensive care settings.

In this case series, we present four patients with different clinical states managed at King Faisal Hospital, Kigali in which a bedside ultrasound scans positively influenced their management in the intensive care unit.

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Case report 1: Ultrasound to confirm central venous catheter placement

A 73-year-old morbidly obese female with hypertension and diabetes was admitted to our intensive care unit with altered level of consciousness and shock evidenced by her cold extremities, increased capillary refill time, and hypotension (blood pressure of 78/41 mmHg). Initial resuscitation was performed in the emergency department which included endotracheal intubation, a bolus of one liter of normal saline, and glucose-insulin therapy. A Foley catheter was inserted but this failed to drain urine, which raised suspicion for anuria. Initial blood samples for laboratory examinations were taken and she was immediately sent to our intensive care unit.

On arrival at the ICU, noradrenaline was started to achieve a MAP of 65 mmHg and she was scheduled for urgent hemodialysis. A dialysis catheter was inserted in the right internal jugular vein and immediately following this a left internal jugular catheter was inserted. A post-procedure chest X-ray (Figure 1) was obtained to confirm the correct placement of both central lines and endotracheal tube placement. However, she developed a tension pneumothorax which was confirmed with a bedside ultrasound and a right chest tube was immediately inserted.

Figure1: *Chest X-ray demonstrating correct placement of central venous catheter*

A search for the cause of the pneumothorax was subsequently initiated. Among the differentials were the complication of central lines passed since pneumothorax could complicate the procedure and the process of airway management vis-à-vis endotracheal intubation. The supine chest-x-ray obtained after the procedure was not conclusive for the left internal jugular vein due to difficult visualization as a result of morbid obesity. The dialysis catheter was seen entering the right ventricle. We then decided to recheck the left central line with agitated saline using bedside USS with a four-chamber cardiac view, and through this, we confirmed correct placement with ultrasound bubble contrast in the right atrium (Figure 2).

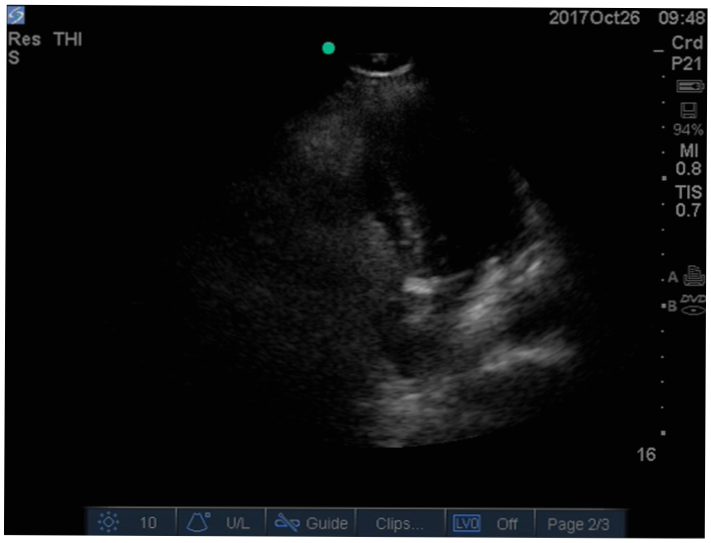

Figure 2: *A four-chamber cardiac USS showing a positive bubble test in the RA following infusion of agitated saline*

Case report 2: Ultrasound to rule out pneumothorax in an intubated and ventilated patient

A 75-year-old female was admitted straight to the ICU for severe asthma that was refractory to continuous nebulization with salbutamol, ipratropium bromide, and magnesium sulphate. She was intubated and commenced on mechanical ventilation due to severe hypercarbia with a PaCO2 of 85 mmHg. The following day, she was observed to be hypoxic with a sharp drop in peripheral oxygen saturation (SpO2) from 100% to 88% with a blood pressure of 210/103 mmHg.

Upon physical examination there was remarkably decreased breath sounds in the right lung zone. A lung ultrasound scan was performed immediately which revealed absence of "lung sliding" in the apex of the same lung (Figure 3). A diagnosis of a right-sided pneumothorax was thus suspected. Urgent chest x-ray was done and while this could not confirm a pneumothorax, it revealed pulmonary infiltrates in the right lung. A chest computer tomography scan could not be obtained because the patient was not stable enough to be moved to the radiological suite. A needle decompression was performed and she improved remarkably. She was successfully taken off mechanical ventilation after about two weeks.

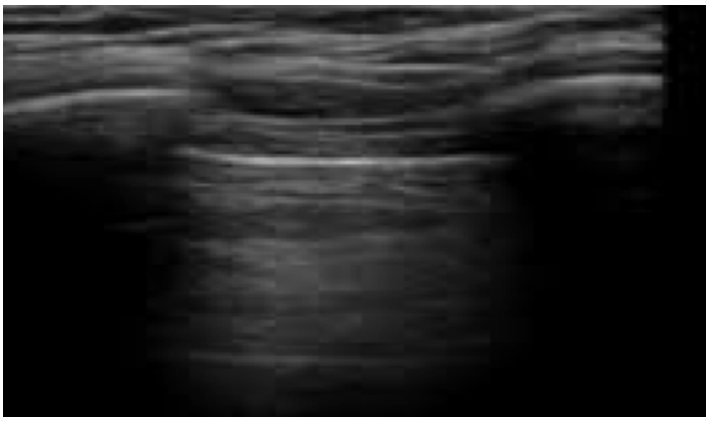

Figure 3: *Lung USS showing absent lung sliding*

Case report 3: Ultrasound for confirmation of free fluid in the abdomen

A 22-year-old male patient without known comorbidities was admitted to the ICU for respiratory support following severe blunt chest trauma sustained in a road traffic accident. He was subsequently intubated for severe respiratory distress and remained hemodynamically stable. However, on his second day of admission his hemoglobin concentration dropped from 14 g/dl to 7 g/dl and he was subsequently transfused three units of packed red blood cells. This necessitated an urgent abdominal ultrasound which revealed moderate free fluid found in the pelvis and Morison's Pouch. An abdominal CT scan was completed and this confirmed hemoperitoneum.

The patient was evaluated by the surgical team and he was taken to the operating room for an explorative laparotomy where the fluid in the abdomen was evacuated, although the quantity was not available. The patient was transferred back to the ICU and was successfully managed and discharged back to the ward after approximately two weeks.

Case Report 4: Ultrasound confirmation of hemoperitoneum

A 71-year-old male patient presented with severe chest pain, difficulty breathing, and abdominal pain following a fall the previous day. The patient had no associated co-morbidities or other chronic illnesses. On admission to the ICU, he was confused and was hypotensive with a blood pressure of 78/45 mmHg, which was managed with fluid boluses.

Upon general examination, the lungs were clear, regular heart sounds were noted on auscultation, and the abdomen was soft and moved with respiration with no area of tenderness. An abdominal ultrasound was performed which revealed free fluid in Morison's pouch and in the pelvis but the patient had become haemodynamically stable, and we decided to observe closely. On the second day of admission, he was found to be in critical status with signs of shock, a blood pressure of 88/40 mmHg, a heart rate of 132 beats per minute, and a respiratory rate of 44 cycles per minute. On physical exam, he had become pale with cold extremities, had a capillary refill time of 3-4 seconds, and had a weak pulse. A repeat abdominal USS at the bedside showed increased free fluid in all quadrants.

He was immediately transfused with three packed red blood cells (PRBC) and three fresh frozen plasma (FFP) and was brought to the theatre for an emergency laparotomy. Intra-operatively, about two liters of fluid blood was evacuated with an additional one litre of clotted blood. Other abdominal findings included severe liver cirrhosis, but no solid or hollow viscous injury nor bleeding vessel was identified. A diagnosis of spontaneous hemoperitoneum secondary to decompensated chronic liver disease was then made. Postoperatively, the patient underwent massive transfusion but unfortunately subsequently developed multi-organ failure and died in the ICU.

DISCUSSION

Traditionally, chest X-ray (CXR) is used for the confirmation of correct placement of a central venous catheter. The incidence of mal-positioning of a central venous catheter (CVC) has been estimated to range from 3.6% to 14% [8]. CXR has been adopted as a necessity after the passage of a central venous catheter, especially for internal jugular vein or subclavian vein cannulation. This is required both for confirmation of correct placement and to rule out complications such as pneumothorax [9].

Correct catheter position has been defined by positioning of the catheter tip at the distal third of the superior vena cava (SVC). This position is said to be optimal to reduce complications such as catheter migration, malfunction, and vascular perforation [10]. This position corresponds to the location of the carina which is easily identifiable on a CXR. A retrospective study conducted in 2006 suggests that all right-sided internal jugular vein catheterization should be placed with the catheter tip above the carina while all left-sided catheter tips should be located below the carina [11]. However, the upper limit of the pericardial reflection of the SVC cannot be visualized on CXR hence the need for cardiac ultrasound in doubtful situations.

In our patient, the tip of the left internal jugular catheter could not be visualized neither in the expected position in the SVC nor in the right atrium (RA) (Figure 1). This led to doubts about its correct position despite its functionality in terms of aspiration of dark venous blood and free flow of injectate through it. To ascertain its position, a four-chamber cardiac view was performed using agitated saline. The bubble was seen entering the right atrium when agitated saline was injected through the catheter (Figure 2).

Previously, ultrasound-guided CVC tip placement at the SVC-RA junction has been found to have an accuracy of 95-100% [12], but its use in the confirmation of correct placement is another dimension to its usefulness when doubts arise. Chest X-ray has been found to be less accurate and less reliable in the confirmation of correct placement of CVC catheters (13). The use of bedside USS confers about 100% accurate confirmation of catheter placement [13], and its use in this regard adds to its other numerous applications in the critical care setting.

A pneumothorax can rapidly progress to a tension pneumothorax which is a life-threatening emergency with subsequent development of cardiac arrest if not recognized and treated early. Conventionally, a pneumothorax is suspected based on clinical presentation and examination and is confirmed with a chest x-ray. However, an antero-posterior view in the supine position is poorly sensitive and often leads to catastrophic misdiagnosis [14]. Our patient was in a supine position in addition to being morbidly obese, further reducing the reliability of the CXR we obtained. A computer tomography (CT) scan of the chest has been described as the gold standard diagnostic tool (15) for pneumothorax, but it is bedeviled with numerous limitations especially in the ICU such as unavoidable delays, transport of unstable patients, high cost, and exposure to radiation.

Lung ultrasound scan, on the other hand, has emerged as a quick

and reliable tool for the diagnosis of pneumothorax in the ICU. It has been found to be superior to a CXR with a sensitivity and specificity greater than 90% [16]. A pneumothorax is diagnosed on a lung USS by the absence of "lung sliding", which refers to the back and forth movement of parietal and visceral pleura sliding on each other with normal respiration and the presence of "lung point", representing the point where the visceral pleura (lung) begins to separate from the parietal pleural (chest wall) at the margin [17]. In addition, the size of a pneumothorax and its consequent implications can also be assessed with the use of "lung point" as a more lateral location suggests a bigger pneumothorax [18]. Our patient had signs of a pneumothorax such as desaturation while being mechanically ventilated and subsequently experienced cardiovascular collapse which prompted confirmation with lung USS. An urgent needle decompression at the second intercostal space and placement of intercostal chest drainage resulted in a positive outcome. Although a chest CT scan could have equally helped in the diagnosis and management of this patient, we did not have the luxury of time to transport this patient hence the importance of the bedside lung USS.

Focused Assessment with Sonography in Trauma (FAST) examinations are an essential component of trauma care to detect the presence of free fluid in the peritoneal cavity with a sensitivity and specificity of 64-98% and 86-100%, respectively [19]. A positive FAST refers to the presence of free fluid either in the Morison's pouch, in the splenorenal recess, or the pelvic region. A FAST examination is quick to perform, requiring < 20 seconds in positive cases, and about 160 seconds in negative cases in experienced hands [20]. The use of FAST has replaced diagnostic peritoneal lavage (DPL) as a primary method of detecting intraperitoneal fluid.

Furthermore, FAST examination has been contemplated in the evaluation of spontaneous hemoperitoneum in non-trauma patients as it helps in the detection of free intraperitoneal fluid especially in hemodynamically compromised patients [21]. Our third and fourth patients rapidly deteriorated after admission to the ICU with a sharp drop in hemoglobin concentration with clinical signs of shock. A FAST examination performed at the bedside revealed a large amount of blood in the Morison's pouch which prompted surgical consultation and review with consequent intervention in the operating theatre.

In the fourth patient, intraoperative findings were suggestive of spontaneous hemoperitoneum secondary to chronic liver disease. Spontaneous hemoperitoneum may result from various causes such as gynecologic, hepatic, splenic, vascular, or coagulopathic conditions [22]. It frequently presents with acute abdominal pain with or without hemodynamic collapse. Like in our patient, hemodynamic collapse may become obvious only after the initial evaluation which implies that spontaneous hemoperitoneum should be detected rapidly during the evaluation. There was no obvious external bleeding or other causes of cardiovascular collapse in this patient. A rapid and reliable bedside USS of the abdomen came to our rescue in identifying the cause of the hemodynamic instability we observed in our patient.

The regular use of beside USS in the ICU in a resource-limited environment like ours is hampered by relative unavailability of an USS machine in most ICU settings. The presence of skilled operators and reliability of results as compared with CT scan add to the challenges of bedside USS use in our setting. Thus, there is a need to encourage hospital administrators and government in general to invest in the procurement of dedicated USS machine for ICU use. Regular training and retraining of physicians working in the ICU on the use of bedside USS cannot be overemphasized.

CONCLUSION

Ultrasound is quick, reliable, and has the potential to influence patient outcome positively. In addition, it is cost-effective and safe to use for all categories of ICU patients. Deployment of this simple but effective tool is a step in the right direction in the quest for improved patient care in the ICU

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