



Systematic use of point of care ultrasound in neurosurgical intensive care unit: a practical approach

Bibesh Pokhrel^{1^}, Amit Thapa^{2^}

¹Department of Neurosurgery, Kathmandu Medical College Teaching Hospital (KMCTH), Kathmandu, Nepal; ²Department of Neurological Surgery, Kathmandu Medical College Teaching Hospital (KMCTH), Kathmandu, Nepal

Contributions: (I) Conception and design: A Thapa; (II) Administrative support: A Thapa; (III) Provision of study materials or patients: Both authors; (IV) Collection and assembly of data: Both authors; (V) Data analysis and interpretation: Both authors; (VI) Manuscript writing: Both authors; (VII) Final approval of manuscript: Both authors.

Correspondence to: Prof. Amit Thapa, MBBS, MS, MCh, IFAANS. Head of Department of Neurological Surgery, Kathmandu Medical College Teaching Hospital (KMCTH), Kathmandu, Nepal. Email: dramitthapa@yahoo.com.

Background: Point of care ultrasound (POCUS) is a cost-effective, non-invasive procedure with high diagnostic reliability and therapeutic utilities. For various reasons, it is not being used routinely in neurosurgical intensive care unit (ICU). We have introduced a systematic use of POCUS in critically ill patients in our neurosurgical ICU. We have studied the various indications and benefit of using this technique.

Methods: This is a prospective, single center cohort observational study done in patients who were admitted in a tertiary neurosurgical ICU over 1 year (17th September 2020 to 16th September 2021). POCUS was used daily as per a standardized format for multiple purposes. A formal training to the operator was provided and standardized method of evaluation and intervention was used. Outcome was studied to understand the impact of the POCUS and difficulties encountered during its use.

Results: POCUS was used in 240 patients, including all patients for primary and secondary surveys, 192 patients (80%) for optic nerve sheath diameter (ONSD) measurement, 14 myelomeningoceles for transfontanelle ultrasound study, 16 post operative cases of aneurysm clipping for transcranial Doppler (TCD) study, 86 patients for deep vein thrombosis (DVT) screening, 17 for evaluation of ventriculo-peritoneal (VP) shunt functionality, 30 for transcranial defect ultrasound, 45 for chest ultrasound, 4 for evaluation of hemodynamic shock and 67 patients who had difficult cannulation or while insertion of central venous catheter placement. POCUS was also used for difficult cannulation, central catheter placement and e-FAST scan. Significant findings were reported 129 times, which led to immediate change in management in 62 patients (25.83%) as compared to 16 patients in whom significant findings were not reported using POCUS, but management was changed using other radiological modalities ($P < 0.01$). There was initial lag in adopting the technique, however with practice, the team developed confidence. As a result, the accuracy and time taken to perform the procedure was reduced significantly.

Conclusions: Routine systematic use of POCUS can be beneficial not only for the rapid diagnosis and prompt management of patients, but also helpful in monitoring and performing various procedures in neurosurgical ICU. Though not all modalities mentioned in standardized format was used in all patients, use of this format has helped improved training and maintain proper use of POCUS in our ICU.

Keywords: Point of care ultrasound (POCUS); neurosurgical intensive care unit (ICU); ultrasonography (USG); sonoscopy

[^] ORCID: Bibesh Pokhrel, 0000-0002-1997-9859; Amit Thapa, 0000-0003-1896-3115.

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Introduction

Bedside ultrasonography (USG)/sonoscopy procedures, also known as “Point Of Care Ultrasound” (POCUS), is a cost-effective, non-invasive procedure which provides real time information and is more specific in diagnostic and therapeutic utilities (1). POCUS has been shown to be a superior imaging option than conventional imaging technique in emergency and critical care setting by minimizing mobilization, reducing cost, assist in invasive procedures and assess the condition in real time (1-3). Various authors have used POCUS in different ways for independent brain pathologies (4-11). However, it is not being routinely used in neurosurgical intensive care unit (ICU) due to steep learning curve and confusion with which modality to use. POCUS being problem oriented rather than organ guided approach has been felt to have minimal use in neurosurgical ICU.

POCUS hands-on courses were commenced in Kathmandu Medical College Teaching Hospital (KMCTH) (1st course was held in 2014) (12). Understanding the aforementioned concern and confusion related to POCUS, we introduced a systematic use of sonoscopy in critically ill patients in our neurosurgical ICU to not only perform and record POCUS modalities systematically but also improve communication, record keeping and training. We studied the various indications and benefits of using the sonoscopy and hereby providing a practical layout of the procedure.

The objective of this study is to know indications and methods used for POCUS based procedures; to provide a general description of these bedside procedures and to evaluate its effectiveness in changing the management in a neurosurgery ICU setting. We present the following article in accordance with the STROBE reporting checklist (available at <https://qims.amegroups.com/article/view/10.21037/qims-22-667/rc>).

Methods

This is a prospective, single center cohort observational study done in patients who were admitted in neurosurgical ICU of KMCTH over one year (17th September 2020 to 16th September 2021). POCUS was used daily as per a

standardized format sheet (*Figure 1*) for multiple purposes for the management of various neurosurgical and non-neurosurgical conditions. The format was comprehensive to include all possible modalities applicable in ICU setting, however some were to be performed based on the indications and patient's scenario. The findings or interventions were recorded on the format sheet. The procedures mentioned in the standardized format helped guide the operator to perform the procedures in an order.

POCUS was used for primary resuscitation, daily secondary surveys including optic nerve sheath diameter (ONSD) measurement, trans-fontanelle evaluation, transcranial Doppler (TCD), screening for deep vein thrombosis (DVT), ventriculo-peritoneal (VP) shunt functionality and transcranial defect ultrasound and focused ultrasound chest and evaluation of hemodynamic shock. POCUS was used to place central venous lines, difficult cannulation, pleural and trans-fontanelle tapping.

Residents on duty were formally trained and asked to perform at least 10 studies or procedures under supervision before independently performing the examinations. Standardized method of evaluation and intervention was used. Outcome was studied to know the impact of the POCUS and difficulties encountered during its use.

Statistical analyses were performed with SPSS 23.0 (SPSS, Inc., Chicago, IL. USA). Pearson Chi square was used to check for significance with $P < 0.05$.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional review board of KMCTH (No. 04082022/05) and informed consent was taken from all the patients and patients' parents or legal guardians.

Technique used

ONSD measurement

Increase in intracranial pressure (ICP) leads to papilledema where cerebrospinal fluid (CSF) collects arounds optic nerve limited by duramater, distending the optic disc. The resulting expansion of ONSD suggests increase in ICP. ONSD measurement is indicated in patients with any intracranial pathologies that can increase ICP in turn rising ONSD values.

KATHMANDU MEDICAL COLLEGE & TEACHING HOSPITAL
Department of Neurosurgery
Sinamangal, Kathmandu, Nepal

Bedside USG

Name: _____ Age/Sex: _____ DOA: _____
 Diagnosis: _____ Date of examination: _____
Optic Nerve Sheet Diameter: Left: _____ Right: _____

Transcranial Doppler: Left Right
 Velocity (cm/sec) Middle Cerebral Artery: Middle Cerebral Artery:
 Internal Carotid Artery Internal Carotid Artery:
 Lindegaard ratio: Lindegaard ratio:

If indicated (ACom, PCom, ACA)

Deep Vein Thrombosis scan: Left Right
 (compressible, echogenic mass) Femoral vein: Femoral vein:
 Popliteal vein: Popliteal vein:

Trans-Fontanelle: Size of lateral ventricles at level of foramen of Monroe
 Left: _____ Right: _____

Other findings: _____

Lung (BLUE protocol)

RIGHT LUNG	NORMAL/ABNORMAL	LEFT LUNG	NORMAL/ABNORMAL
UPPER BLUE POINT		UPPER BLUE POINT	
LOWER BLUE POINT		LOWER BLUE POINT	

Inferior VenaCava Size: compressible kissing % collapse during expiration
VP shunt functionality: flow present Y N
 while chamber pressing Y N
 Free fluid in peritoneum Y N

Trans defect in Decompressive Craniectomy:

Sonoscopic guided procedures:
 CVP placement
 A line, Difficult Cannulation
 Pleural/ Trans-fontanelle tapping

Figure 1 POCUS record form for neurosurgical ICU. USG, ultrasonography; DOA, date of admission; ACom, anterior communicating artery; PCom, posterior communicating artery; ACA, anterior cerebral artery; BLUE, bedside lung ultrasound in emergency; VP, ventriculo-peritoneal; CVP, central venous pressure; POCUS, point of care ultrasound; ICU, intensive care unit.



Figure 2 Placement of the probe for ONSD measurement. A clear covering (e.g., tegaderm) may be used to avoid direct contact of gel with the eyelid. This image is published with patient's party consent. ONSD, optic nerve sheath diameter.



Figure 3 ONSD measured 0.30 cm below the globe. ONSD, optic nerve sheath diameter.

ONSD is measured by using linear probe of the ultrasound in B mode with patient in supine position with the examiner at the head of the examination table with head elevated for 20°–30°. The ideal situation would be to instruct the patient to look straight with eyes closed without moving the eyeball. However, in ICU settings we place the probe with gel over the upper eyelid with wrist resting on forehead to avoid putting pressure on the eye (*Figure 2*). The optic nerve is visualized posterior to the globe in axial plane. Once optic nerve and surrounding sheath is



Figure 4 Placement of the probe for transfontanelle measurement. This image is published with patient's parents consent.

visualized, freeze button is clicked and ONSD measurement is taken 3 mm behind the globe perpendicular to the optic nerve axis (*Figure 3*).

Trans-fontanelle evaluation

Trans-fontanelle evaluation of the head is done for neonates through the open anterior fontanelle for intracranial or spinal pathologies. Curvilinear probe of the ultrasound is used to assess the fontanelle opening in B mode to look for the size of lateral ventricle. The head of the child is held by an assistant, gel applied and trans-fontanelle POCUS is done. To look for the coronal image, the probe is angled to depict the frontal horns of the lateral ventricles.

Trans-fontanelle tapping of CSF can be done in case of distended ventricles. Under ultrasound guidance, a butterfly cannula is inserted into the frontal horn of lateral ventricle using aseptic measures. CSF is then allowed to flow out. Sterile dressing is applied at the puncture site (*Figures 4–6*).

TCD USG

TCD USG is being used to study cerebral hemodynamics for the evaluation of stenosis, vasospasm and occlusion of cerebral arteries; mainly done after an aneurysm clipping surgery.

We used 3 MHz Doppler probe in Doppler and color mode for the evaluation of blood flow signals mainly in the anterior, middle and posterior cerebral arteries and internal carotid arteries through a thin temporal window directing the probe towards contralateral side. Blood flow velocity is then measured in cm/s for the arteries of interest. When



Figure 5 Measurement of the size of frontal horn of left lateral ventricle. With serial monitoring, the size can be appreciated.

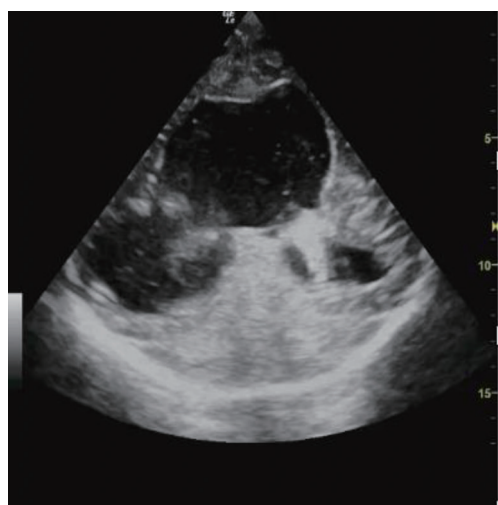


Figure 6 Trans fontanelle ultrasound showing dilated ventricles in a case of congenital hydrocephalus.

evaluating the different arteries, the depth of the artery and the color that the arteries exhibit were used to identify different arteries. Lindegaard ratio was then calculated by dividing the mean velocity of middle cerebral artery to that of internal carotid artery, which helped to differentiate hyperemia from true vasospasm (*Figures 7,8*).

Transcranial defect ultrasound

Hemicraniectomy provides a wide window for intracranial imaging with images comparable to magnetic resonance imaging (MRI) and computed tomography (CT) scan. Transcranial defect ultrasound was used to look for the

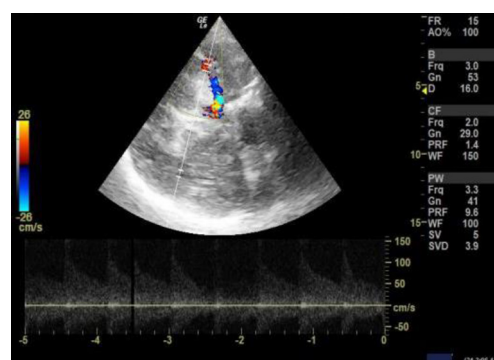


Figure 7 TCD measurement through a transtemporal view in Doppler mode, red/blue color suggestive of blood flow towards/away respectively, thereby suggestive of the artery. TCD, transcranial Doppler.

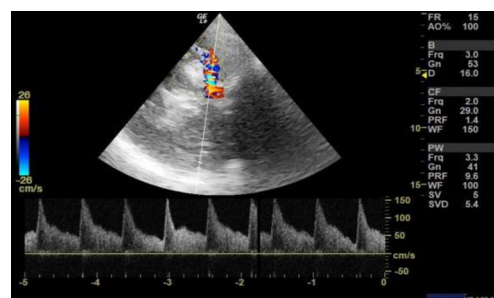


Figure 8 TCD measurement, the depth of artery and color suggestive of blood flow away from the probe suggestive of anterior communicating artery. Here the velocity is around 150 cm/s. TCD, transcranial Doppler.

ventricle size, size of hematoma or collections, midline shift and brain stem in patients who have undergone hemicraniectomy after trauma to the head. Curvilinear probe was used for the evaluation in B mode. Gel was applied over the hemicraniectomy side and the probe is rotated to look for the above-mentioned pathology in real time (*Figures 9-11*).

VP shunt functionality

We used ultrasound to check for VP shunt patency and whether the shunt is functional or not for patients after a VP shunt surgery. After localizing the shunt by palpation, a linear ultrasound probe was kept over the tube just distal to shunt chamber. M mode was turned on. The shunt chamber was then pressed and to check whether there was a flow in the tube which can be visualized in M mode.

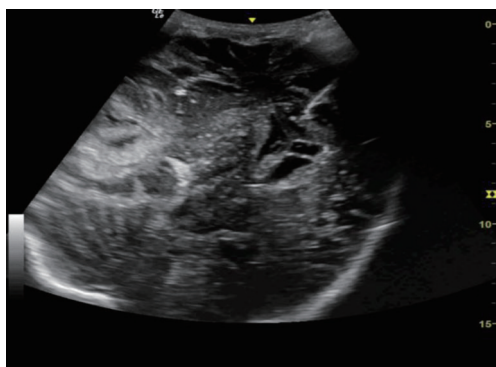


Figure 9 Transcranial defect ultrasound with a curvilinear probe in B mode of an adult showing diffuse brain swelling with effaced lateral ventricle.

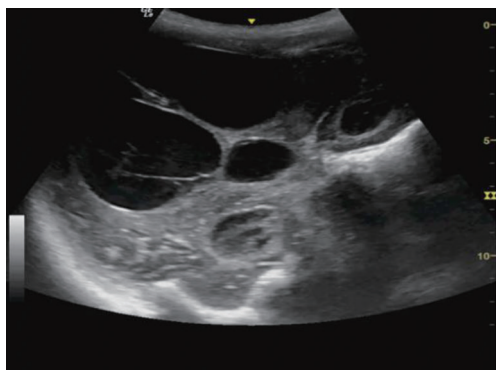


Figure 10 Transcranial defect ultrasound of an adult patient showing septations within enlarged 3rd ventricle and lateral ventricles, suggestive of hydrocephalus.

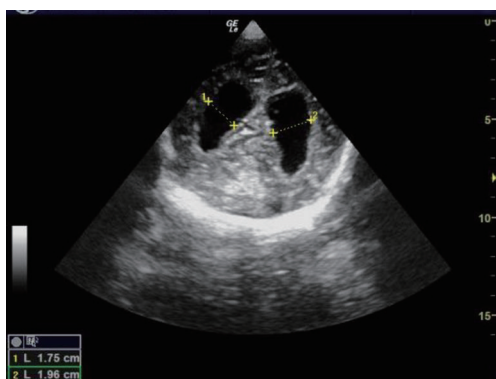


Figure 11 Transcranial defect ultrasound of a hemispherectomy patient in whom the size of the lateral ventricle is measured. This can be compared in serial monitoring.

Ultrasound abdomen was also done to look for free fluid in the peritoneal cavity which indirectly suggested flow of CSF through VP shunt into peritoneal cavity (*Figure 12*).

Ultrasound lungs

As patients admitted to neurosurgical ICU are at risk of developing ventilator associated pneumonia, we find daily lung ultrasound screening a useful alternative to chest X-ray (CXR) or CT chest. Besides we looked for pneumothorax, pleural collection and pleural effusion that needed immediate management in patients with an ICU stay of >3 days.

We used a 5 MHz curvilinear probe and evaluated the lung zone according to the blue points (bedside lung ultrasound in emergency, BLUE protocol) as shown in *Figure 13*. Upper BLUE point is at 1 cm below the clavicle at the midclavicular line. Lower BLUE point is lateral to the nipple in the anterior axillary line. The posterolateral point lies in the intersection of posterior axillary line and horizontal line along the nipple. The probe can be moved in any direction in order to get more information. The point of interest is the chest wall, pleural space, lung parenchyma and the diaphragm.

As air generates artifacts during lung ultrasound, knowledge of the normal pattern is needed to perform and interpret the results. There is a narrow window for ultrasound between the ribs which casts posterior acoustic shadow. At around 1 cm below the skin, we can appreciate a hyperechoic pleura which slides forward and backwards with respiration and a 'bat sign' (pleural line in between two ribs) as shown in *Figure 9* which is a normal finding. We then used the M-mode (time motion) to check for either a normal 'seashore sign' (*Figure 14*) or a 'barcode sign' to diagnose pneumothorax (*Figure 15*). Then the probe is kept at zone 2 and checked for the same. Probe is then placed at zone 3 and looked for any collections. Appreciating a hypoechoic or anechoic homogenous collection is suggestive of collection or pleural effusion (depending upon the amount of collection) in the dependent part of the thoracic cavity above the diaphragm. A syringe is taken to aspirate pleural fluid under ultrasound guidance.

Screening for DVT

Neurosurgical ICU patients are at a risk of developing DVT as patients are bed ridden. Ultrasound can be used to screen these ICU patients for DVT. Although a proper DVT screening has to scan common femoral, great saphenous,

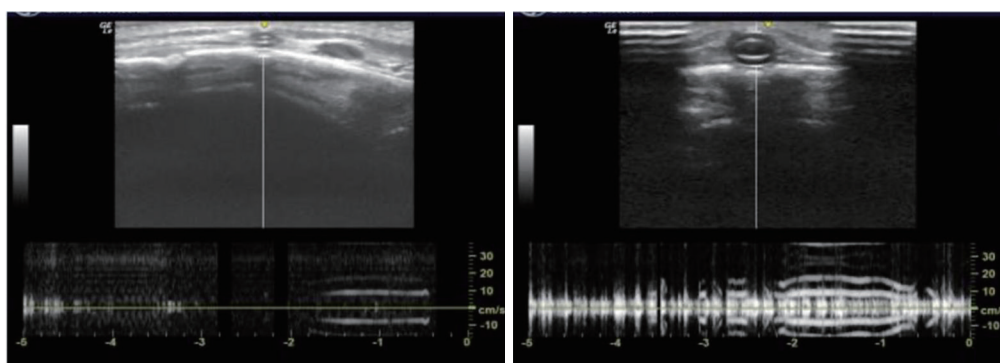


Figure 12 Localization of VP shunt tube and checking the flow in M mode. The flow in the VP shunt is observed distal to the chamber by pressing/releasing the chamber. VP, ventriculo-peritoneal.



Figure 13 Standardized BLUE protocol points over right side of the anterior and lateral chest wall. BLUE, bedside lung ultrasound in emergency.

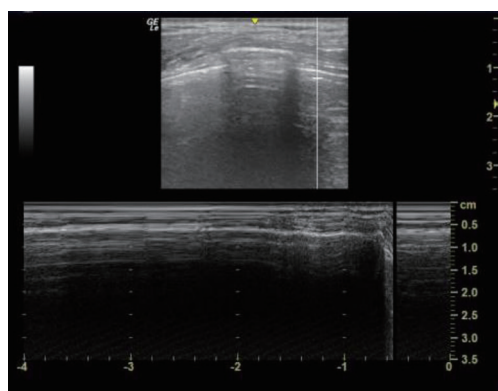


Figure 14 Lung ultrasound to check for lung sliding in M mode. Here a Seashore sign can be seen which is a normal finding.

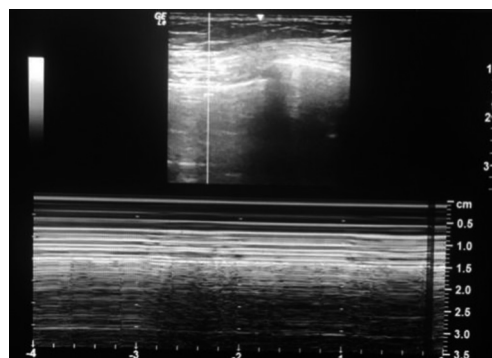


Figure 15 M mode lung ultrasound showing a Barcode sign, suggestive of pneumothorax.

superficial femoral, deep femoral, popliteal, posterior tibial, and peroneal veins; this can be time consuming in ICU settings. So, we looked for compressibility and collapse of common femoral and popliteal veins only (*Figures 16,17*).

Linear probe was kept at the calf and groin on both sides respectively. M mode was used to check for the flow in the veins.

Other scans

Inferior vena cava (IVC) diameter was measured in supine position by placing a 5 MHz probe in subxiphoid location in sagittal section 2 cm proximal to junction of hepatic vein and IVC and diameter was measured in M mode. IVC diameter can be useful to check if a patient has deteriorated cause of hypovolemia or fluid overload. Ultrasound was

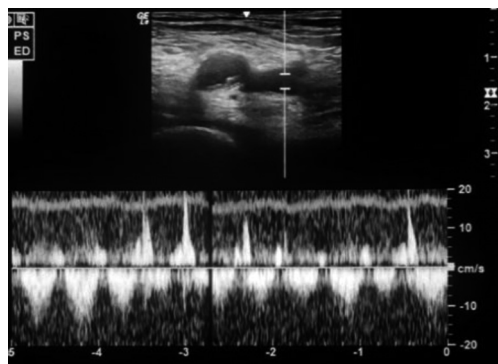


Figure 16 DVT screening in M mode showing the flow in popliteal vein in M mode using a linear probe. DVT, deep vein thrombosis.

also used for other purpose like central venous catheter placement, difficult cannulation, arterial line placement, urinary bladder scan and e-FAST scan.

Results

A total of 240 neurosurgical ICU admissions were studied after being taking consent. The number of patients enrolled according to the underlying disease is given in *Table 1*. The use of standardized format helped maintain homogeneity of protocols and was found to be good teaching tool. It also served to communicate efficiently. Different modalities of ultrasound as mentioned in the standardized format were used for all ICU patients according to the protocol (*Figure 1*), however the modality/type of intervention performed depend upon the need of the patient (*Figure 1*).

All patients in whom POCUS detected an abnormal finding, formal investigations/definitive procedure was performed. The number of significant findings and interventions done for each modality assessed is shown in *Figure 18*. All the images were saved in the sonoscopy machine, which was then reviewed for accuracy of the finding and result and corrections to maintain a required standard for the study. Routine screening and follow up of all enrolled patients were done according to the protocol till the patients were shifted from neurosurgical ICU.

Trans-fontanelle tapping was done in neonate with hydrocephalus under ultrasound guidance and around 10 to 30 mL of CSF was aspirated according to the size of ventricle. Similarly, pleural tapping was done for a patient with a massive hemothorax. POCUS was used for placement

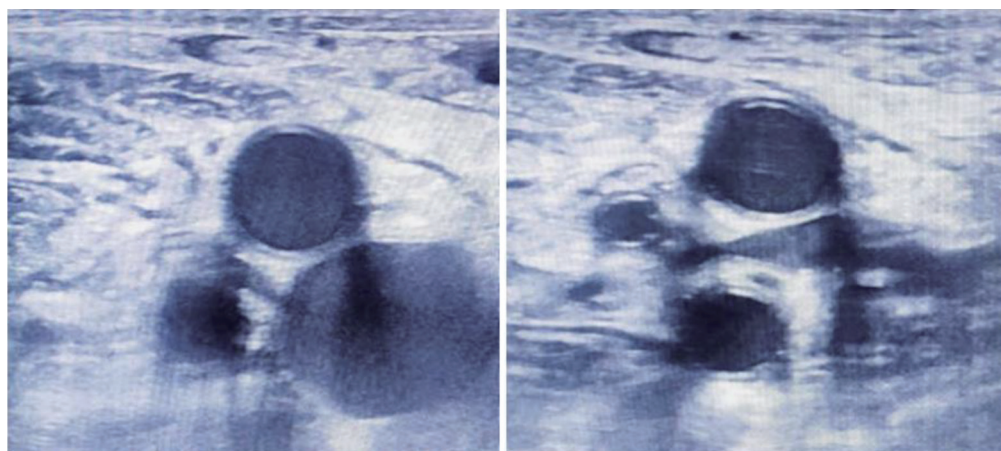


Figure 17 Checking the compressibility of the femoral vein by pressing the probe to the skin in B mode.

Table 1 Number of patients enrolled according to the underlying diseases

Underlying disease	Number of patients screened
Traumatic brain/spine pathologies	99
Spontaneous hemorrhage/ischemic stroke	66
Brain tumor	26
Aneurysm	16
Meningomyocele	14
Brain infection	14
Other brain pathologies	5

of central venous catheters, arterial line placement as well as in difficult cannulation.

Out of the 240 neurosurgical ICU admissions, modalities mentioned above were used for 471 times. The age of patients ranged from 3 days to 87 years, with 63.7% male. Single modality of POCUS was used in 27.6%, while two or three modalities were used in 29.7% each (*Figure 18*).

POCUS allowed for timely diagnosis and of significant findings in 62 patients (25.83%) (*Figure 18*). This has led to effective change in management in 48.1% as compared to 11.1% cases in which POCUS failed to identify significant findings (which were picked on other radiological investigations) who later required intervention ($\chi^2=30.7909$, $P<0.001$) (*Table 2*). None of the patients had any adverse effect after being enrolled in this study.

Discussion

POCUS is a non-invasive procedure, which is becoming an integral part in care and management of patients as it provides a real time information. It is also helpful in assessing progress of the disease and response to specific treatment (13). POCUS can be done bedside without mobilizing patient to minimize risk, reducing cost and monitoring complications. It also helps in invasive procedures that are done in neurosurgical ICU (14).

The four pillars during bedside physical examination are to inspect, palpate, percuss, and auscultate. Incorporating appropriate technology (bedside ultrasound or POCUS) can not only improve the performance but also assist in superior decision making. Thus, making bedside ultrasound the fifth pillar of physical examination (15).

We have described our systematic approach to use of

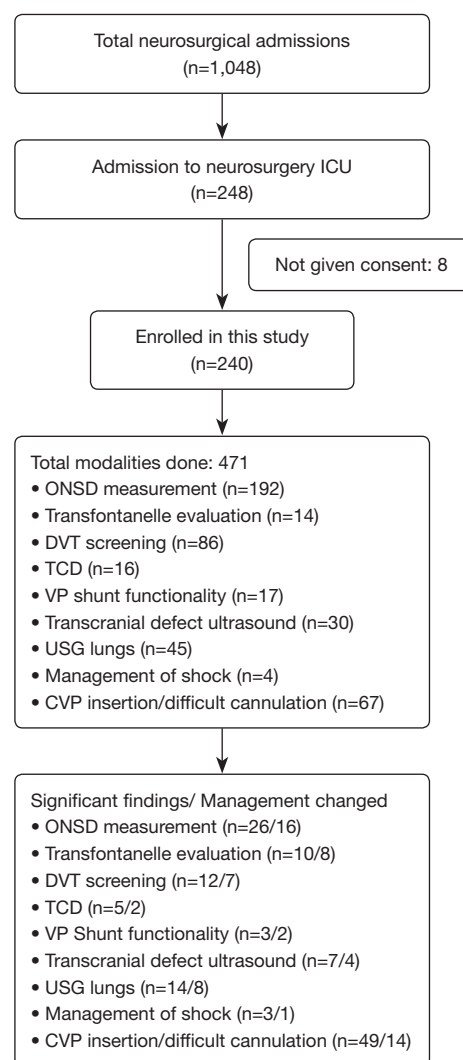


Figure 18 Patient selection flowchart with different POCUS based study/procedures and number of patients with additional interventions performed for abnormality detected in each POCUS modality. ICU, intensive care unit; ONSD, optic nerve sheath diameter; DVT, deep vein thrombosis; TCD, transcranial Doppler; VP, ventriculo-peritoneal; USG, ultrasonography; CVP, central venous pressure; POCUS, point of care ultrasound.

POCUS in our neurosurgical ICU. This has maintained uniformity and proved to be a good teaching tool. In almost half of the cases, where significant findings were noted, we were able to perform timely intervention.

Of all the modalities, ONSD was most commonly used in our ICU. ONSD measurement is a simple, non-invasive procedure with high diagnostic accuracy for intracranial hypertension. Maissan *et al.* stated that if ONSD >5.0 mm;

Table 2 Table showing outcome of significant findings on POCUS (P<0.001)

Significant finding on POCUS examination	Intervention		Total (P<0.001)
	Not required	Performed	
Absent	95	16	111
Present	67	62	129
Total	162	78	240

POCUS, point of care ultrasound.

ICP being >20 mmHg is 94% sensitive and 98% specific (16). As the intracranial CSF spaces are a continuum with optic nerve subarachnoid spaces; any acute or chronic disease with increased ICP can lead to the increase in ONSD. In this study, two or more values of ONSD >6 mm was considered a significant finding.

Many authors have described several intracranial windows for ultrasound, but they are rarely performed (6). Transcranial POCUS in a hemicraniectomy patient provides a unique window for evaluating various pathologies which has been reported to identify important intracranial pathologies (13,17). Although, a B mode ultrasound can be done in patients with intact skull, the visibility becomes far better when the bone flap is removed. In this study, size of ventricles, hematoma or collections and midline shift was evaluated in serial monitoring to monitor the underlying intracranial pathologies. Transtemporal windows is another commonly performed window for the evaluation of vasospasm of cerebral arteries. Owing to an open fontanelle and thinner transtemporal window in neonates and infant, the imaging has shown to be highly sensitive and specific to that of an adult hemicraniectomy patient (6). Although, authors have often reported the window to difficult, time consuming and inadequate in adults (18), TCD in aneurysmal subarachnoid hemorrhage, however, has shown to be an important modality for monitoring of vasospasm (8). Lindegaard ratio of <3 is considered normal with values of 3.0–4.5, 4.5–6 and >6 indicative of mild, moderate and severe vasospasm respectively (5).

Trans-fontanelle ultrasound outstand many clinical situations benefitting the patients that requires sedation in an unexpensive and non-invasive way (10). Recently [2020], The American Institute of Ultrasound in Medicine (AIUM) has published a consensus for cranial ultrasound in infants for various cranial conditions and monitor hydrocephalus (19), highlighting ultrasound being an extremely valuable tool. Trans-fontanelle tapping has been described in literature

done in either brain abscess (11) or in subdural empyema (7). In this study, serial monitoring of the size of ventricles were done to monitor for hydrocephalus. We used tapping to send CSF culture or in neonates who required shunting but parental refused to consent.

Using ultrasound to check for the functionality of VP shunt has not been reported in the literature. Using ultrasound to check for the blockage or a non-functional VP shunt including presence or absence of collection in the abdomen can be helpful in the management of VP shunt.

There are adequate papers published highlighting the importance of lung POCUS in emergency as well as in ICUs (1-3,15). It has shown to be a good alternative to thoracic CT and CXR to diagnose common lung pathologies (2). Out of many lung ultrasound protocols, this study uses the BLUE protocol in neurosurgical ICU setting (20). A standardized thoracic point in BLUE protocol is adapted in this study which gives a uniform, accurate findings. Additionally, it is easy to perform because all life threatening conditions of the chest are superficial. This study only focused on pneumothorax, pleural collection and pleural effusion which are more common in neurosurgical ICUs.

A complete DVT screening including both the lower extremities and the calf veins is time consuming (21), especially in case of neurosurgical ICUs. Compression testing of the proximal veins is sufficient for evaluation of DVT (22), with authors claiming a diagnostic accuracy of around 95% (1). In this study, 8.1% of DVT screened patients had a positive POCUS findings which was correlated with repeated DVT scan and managed accordingly.

Out of many roles of POCUS, evaluation of hemodynamic shock is also one of the important techniques in neurosurgical ICU to know the fluid status. Aggressive fluid resuscitation can be detrimental for patients in shock. Measurement of IVC diameter helps in the detection of hypovolemic shock as well as following up on hypovolemic patients and responding to fluid challenge (23). Although neurosurgical ICU patients have central venous pressure (CVP) catheter inserted, studies have shown CVP should not be used to guide clinical decisions regarding volume management (24,25). As IVC diameter is minimally affected by compensatory response of body to fluid loss, it is more reflective than other arterial parameters such as blood pressure or pulse rate (26).

There are many studies describing new approaches for diagnosing different neurosurgical condition, however due to lack of proper evidence, further studies are required. In this study, only the POCUS modality useful in neurosurgery

ICU has been described which helped in patient management and to guide the treatment. It was used in primary resuscitation for evaluation of chest and evaluation of hemodynamic shock in life threatening emergency conditions; and in daily secondary surveys including ONSD measurement, trans-fontanelle evaluation, TCD, DVT screening, VP shunt functionality and transcranial defect ultrasound.

Although, POCUS in neurosurgical ICUs can never replace gold standard imaging modalities, it can be a useful tool to increase potential ability while using fewer resources (6). POCUS is becoming increasingly popular, with many authors strongly suggesting to add POCUS to the ICUs (17) and to train the neurosurgical residents eventually leading to the betterment of patient care.

Challenges and limitations

There was an initial lag in adopting the technique to be familiar with the imaging appearance. Although POCUS has an operator dependent image acquisition; the team developed confidence by teaching and learning modality, leading to accurate results and reduced time taken to perform the procedure. Poor sonography images, interpretation of results, inter-observer differences, human resource management and adapting to the ultrasound machine were some of the difficulties faced during this study. The diagnostic reasoning, judging a diagnostic impression or conforming a specific hypothesis could have led to cognitive, anchoring or conformation bias.

Conclusions

Routine systematic use of ultrasound can be beneficial not only for rapid diagnosis and prompt management of patients, but also to perform various procedures in neurosurgery ICU. POCUS has also changed the paradigm in patient management by decreasing complications associated with various procedures performed in neurosurgery ICU. Incorporating POCUS into critical care training is increasing because it is beneficial for both the patients and the treating physician.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at <https://qims.amegroups.com/article/view/10.21037/qims-22-667/rc>

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at <https://qims.amegroups.com/article/view/10.21037/qims-22-667/coif>). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional review board of KMCTH (No. 04082022/05) and informed consent was taken from all the patients and patients' parents or legal guardians.

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