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A Narrative Review:The role of preoperative POCUS in patients with hip and femur fractures

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ABSTRACT

The application of point-of-care ultrasound (POCUS) in clinical anesthesia practice is becoming well established. In this narrative review, we discuss the perioperative use of POCUS beyond venous access and regional anesthesia techniques in patients scheduled to undergo repair of hip or femur fractures.

POCUS has gained widespread value in the evaluation of various organs and systems including the stomach, lungs and heart due to its simplicity, availability, safety, and capacity to provide important information to clinicians. Hip and femur fractures are relatively common, with a prevalence that increases over age 75. By default, this population is associated with a high rate of comorbidities. Early fixation of these fractures can reduce the risk of complications, shorten hospital stay, and reduce cost. In this scenario, a comprehensive preoperative patient evaluation is not always feasible. Therefore, POCUS emerges as a valuable tool. In this narrative review, the multiples ways that POCUS can be used are explored including the most common findings and it's implications in clinical practice. Our goal is to show how the application of this technique can guide the management of hip or femur fractures to possibly obtain a better outcome.

Introduction

Hip and femur fractures are relatively common in elderly patients. Whilst in young patients, it requires a strong force to break these bones, in the elderly, low-energy trauma can lead to proximal femur fractures. Especially in this population, these fractures are associated with increased mortality, having both short and long-term consequences.[1] Early surgical fixation is associated with better outcomes. Benefits include lower mortality and reduced risk of complications including pulmonary infection, deep vein thrombosis, surgical infections as well as others. In addition, early repair leads to shorter hospital stays and cost savings.[1,2]

The short period of time between hospital arrival and surgery limits the ability to complete a comprehensive patient evaluation. Quite often due to low physical demand, these patients present with relatively few symptoms but can have significant underlying comorbidities. Although asymptomatic, during the more stress-related perioperative period, these conditions become apparent leading to patient decompensation.[3,4]

Point-of-care ultrasound (POCUS) has gained widespread use throughout the last two decades. It has been a useful tool in several different scenarios as an adjunct to traditional diagnostic methods. Instead of making specific diagnoses, the goal of POCUS is to answer simple yes or no questions to help evaluate and manage patients.[5-9] Once it is more readily available, it can be very useful pre- and postoperatively for patients with hip and femur fractures as well as have a positive impact in postoperative mortality.[5-9] This technique can be used in one or more organs and system depending of patient's clinical picture or physician concerns. Perhaps the most import of them is the cardiovascular system where a rapid assessment of systolic function, gross cardiac anatomy and volume status can be performed. The lung evaluation supports fluid management and helps identify causes of hypoxemia. Evaluation of gastric content is also of great importance. In addition to these high yield POCUS chapters, other exams are mentioned including carotid, bladder, airway, and ocular. So, in this review, we explore multiple applications of POCUS to avoid surgical delay, detect underlying conditions, and/or direct anesthetic management to improve safety and outcomes.

Gastric POCUS

Pulmonary aspiration of gastric contents in patients with hip or femur fractures is a dreaded complication associated with a high morbidity and mortality.[10,11] The American Society of Anesthesiologists recommends a minimum of 2 hours fasting for clear liquids, 6 hours for a light meal or nonhuman milk, and 8 or more hours after a full meal.[12] These recommendations apply for healthy patients undergoing elective surgeries. Some studies have shown that even in this scenario, 5-6% of patients present with an amount of gastric contents that would consider them as having a full stomach.[13] High risk patients, such as those presenting for urgent procedures, may have delayed gastric emptying and despite having fasted for more than the recommended times, have residual content in their stomachs.[14]

Gastric ultrasound has emerged as a very useful tool for assessing the volume gastric contents when the NPO status is uncertain or a patient is high-risk for delayed gastric emptying. This is frequently the situation for patients undergoing surgical hip or femur fracture fixation. Visualization of the gastric antrum without evidence of solid or fluid content and a low cross-section area is reassuring. Multiple factors can lead to slow gastric emptying.[15]

Diabetes can lead to decreased motility as a consequence of nerve damage.[16] This disease affects around 29% of the population over age 65 in the United States, and likely an even higher percentage of patients who suffer from a femur fracture.[17,18] Due to this risk, gastric POCUS should be considered in this population.

Neurological disorders such as Parkinson's disease can also affect gastric emptying.[19] Its prevalence increases with age; 1.0% for those 65 to 74, 3.1% for

those 75 to 84, and 4.3% for those 85 to 94.[20] Patients with Parkinson's disease have an increased risk of osteoporosis. They also have a higher risk of falls due to postural instability, impaired balance, motor, and cognitive function. In addition, medications including dopaminergic medications and antidepressants can contribute to the higher risk of hip and femur fracture.[21] It is reasonable to suppose that the percentage of patients with Parkinson's disease who present with a hip fractures would be higher than the overall. Considering these factors, assessing the gastric content with ultrasound should be considered.

Pain, stress, and trauma are also well-known causes of delayed gastric emptying due to the affect on the autonomic nervous system. Patients who have recently suffered a trauma should all be considered at risk of having retained gastric content, regardless of fasting time.[22,23]

There are several medications that are known to slow gastric emptying. The list includes, but is not limited to: opioids, certain antidepressants, anticholinergics, GLP1 agonists, cannabis/marijuana, calcium channel blockers, immunosuppressants, as well as others.[24]

A myriad of other medical conditions are related to delayed gastric emptying. Gastric dysmotility from rheumatic diseases, systemic sclerosis, autonomic diseases, and viral infections. These are all clinical examples that highlight the value of preoperative gastric POCUS as an assessment tool.

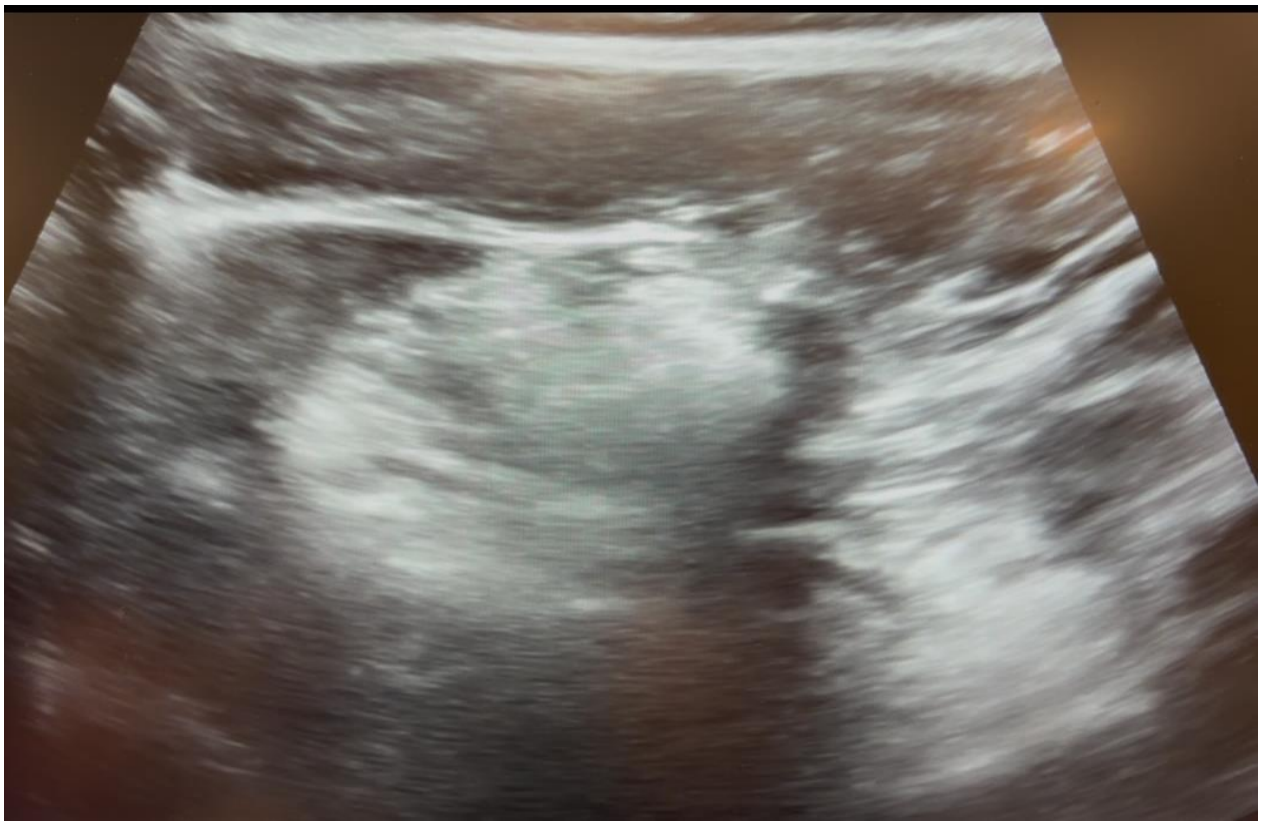
The gastric scan is performed using a curvilinear (low-frequency) probe in the epigastrium in a sagittal plane. The goal is to identify the gastric antrum between the liver and the pancreas. The aorta is an important landmark. (Figures 1-3)

Empty Stomach

Figure 1: Gastric POCUS

Full Stomach; Clear Fluid

Figure 2: Gastric POCUS



Full Stomach; Solid Late Stage

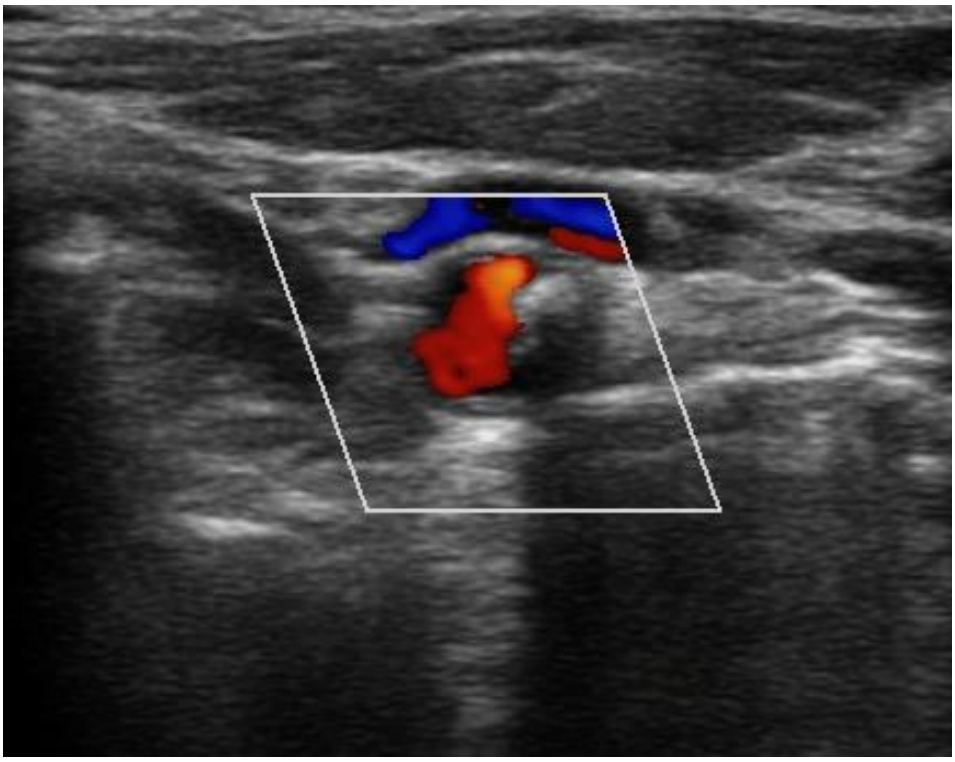
Figure 3: Gastric POCUS

There are some important limitations to consider when performing gastric POCUS in patients with hip and femur fractures. The most significant is positioning. To confirm that the stomach is empty, it is imperative to perform the exam in the right lateral decubitus position which may not be feasible in patients with a hip or femur fracture.[15] The rationale is that in the right lateral decubitus position, gastric contents will dislocate to the antrum. This is the reason why an assessment in the supine position cannot determine if a patient has an empty stomach. Any time solid contents are visualized (frosted glass pattern), the patient is considered to be at a high aspiration risk.[15] The same applies to high volume of fluid content like in figure 2. In this situation, the anesthesiologists has a valid reason to choose endotracheal intubation rather than providing deep sedation or placing a supraglottic device. Other limitations of gastric US include previous gastric resection or bypass, gastric band, fundoplication, and a large hiatal hernia.[15]

In summary, in the setting of hip or femur fracture, gastric ultrasound can provide the anesthesiologist with helpful information to guide decision making regarding aspiration risk and choice of anesthetic.

Carotid Arteries

The prevalence of moderate to severe carotid stenosis increases with age, reaching as high as 12.5% over age 70.[25] A significant portion of these patients are asymptomatic. Carotid ultrasound is a convenient tool for evaluation of carotid atherosclerosis in patients with multiple risk factors.[26] Detection of asymptomatic carotid stenosis can lead to changes in the perioperative care, in particular blood pressure management knowing that periods of hypotension increase the risk of perioperative stroke.[27,28] Image is obtained using the linear high-frequency probe. We start using the B-mode but eventually color can be used to help identifying any obstruction. The scan is typically done in the transverse plan going from the proximal common carotid artery up to the beginning of internal carotid artery. No measure is done, only visual detection is performed. (Figure 4)



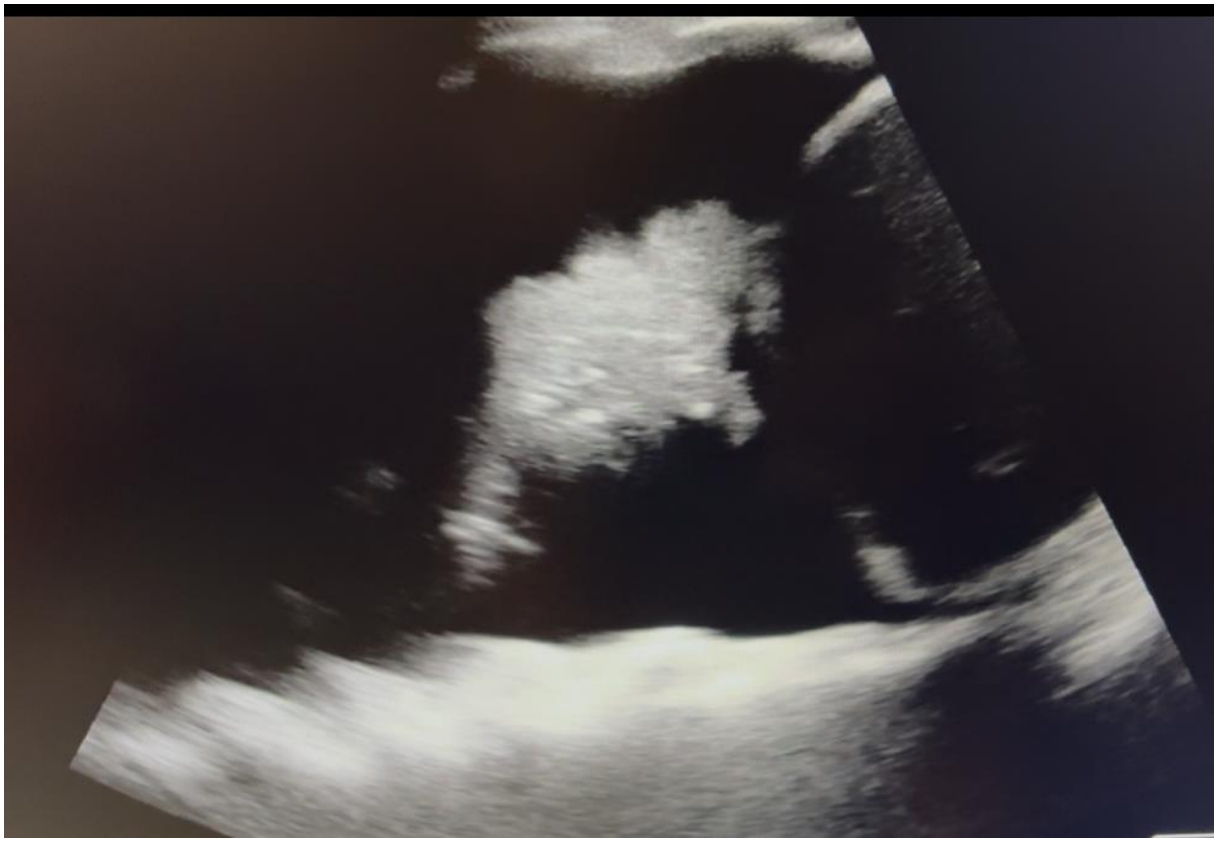
Carotid US performed at bedside immediately before femur fracture fixation showing significant carotid obstruction in an asymptomatic patient

Figure 4: Carotid color US

Lungs

Lung ultrasound is relatively easily done. The low-frequency curvilinear probe is preferred for deeper structures whilst the linear high-frequency shows better shallow structures like the pleura. The importance of lung ultrasound is often underestimated by anesthesiologists but it is widely accepted as a reliable tool for evaluating pulmonary status at the bedside.

It has been shown to help determine the cause of hypoxia in over 90% of cases.[29] For instance, it enables early detection of pre- and postoperative atelectasis. Bed rest increases the risk of atelectasis, which is a prevalent cause of perioperative hypoxemia.[30] It can also easily detect fluid overload as a cause of decreased oxygen levels, while chronic obstructive pulmonary disease (COPD) and asthma usually present with normal lung ultrasound.[6-9] (Figures 5)



Lung POCUS performed at bedside immediately before urgent hip fracture showing pleural effusion and lung collapse. Consolidation of lung tissue is similar in appearance to the liver. A pleural effusion appears as a hypoechoic area between the lung and the diaphragm

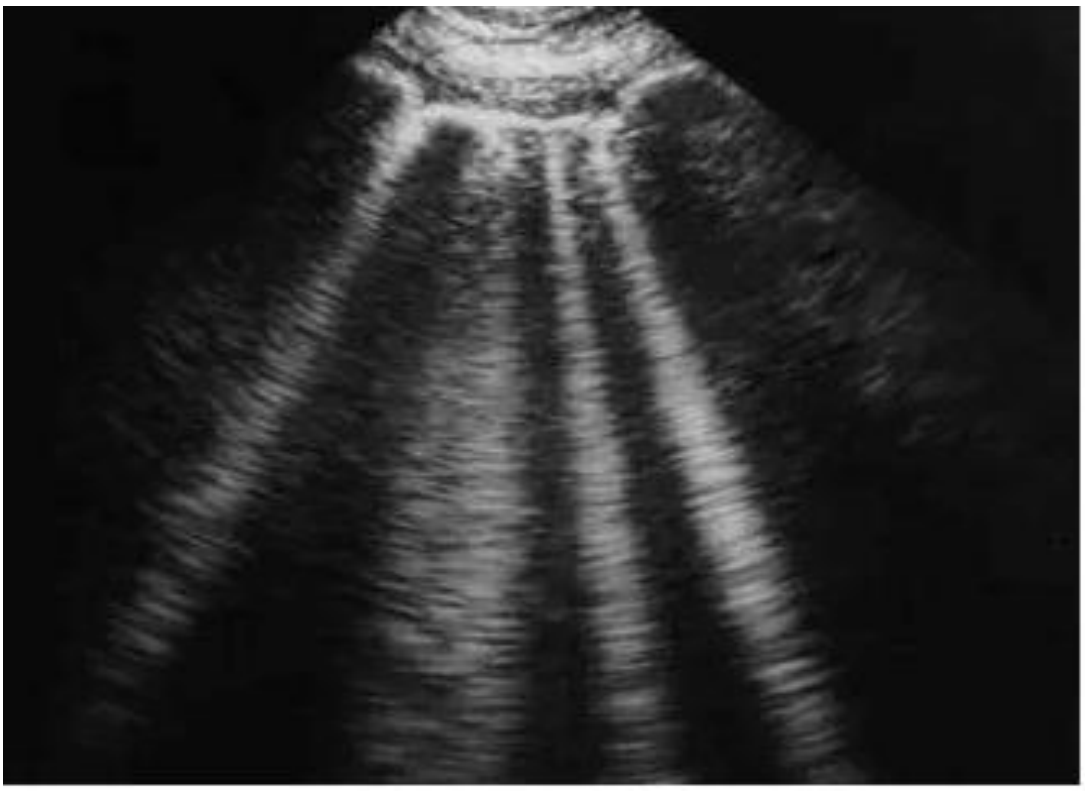
Figure 5: Lung POCUS

Ultrasound findings in a normal lung exam include: lung sliding, A-lines, lung pulse, and B-lines. M-mode can be used to increase accuracy with the "seashore sign" being a normal finding in this mode.[6-9]

The absence of lung sliding and the presence of the "barcode" sign in M-mode suggests possible pneumothorax. The lung point is the dynamic transition point between normal lung sliding and the absence of lung sliding has a 98-100% specificity for the diagnosis of pneumothorax. In M-mode, the lung point is seen as an abrupt transition from "barcode" to "seashore" sign.[6-9]

B-lines are bright, hyperechoic, comet-tail signs that extend from the pleural line to the bottom of the screen without fading. They are seen in normal lungs, but three or more B-lines within the same intercostal space is an abnormal finding. If focal, they point to focal lung diseases, while multiple B-lines in both lungs suggest pulmonary edema. (Figure 6) That's the reason scanning superior and inferior areas of

both lungs is essential. The number of B-lines correlates well with the degree of fluid in the lung and together with cardiac and vascular imaging can guide perioperative fluid therapy. Performing lung ultrasound to detect fluid overload is extremely valuable, especially, when we consider that this condition can be very harmful. It has been demonstrated that excessive intraoperative fluid balance is associated with higher mortality.[31] Decompensated heart failure has a 4-fold higher risk of 90-day mortality. Orthopedic surgery, in particular, has been shown to have a higher risk of mortality.[32] It's important to remember that perioperative pulmonary edema can occur despite normal left ventricle ejection fraction. It's linked with diastolic dysfunction that can be exacerbated by perioperative events such as tachycardia, hypertension, and excessive fluid reposition.[33] Therefore, if heart failure or fluid overload is suspected, lung POCUS should be considered even if there is no left ventricle systolic dysfunction.[6-9]



Lung POCUS showing multiples B-lines in one intercostal space.

Figure 6: Lung POCUS

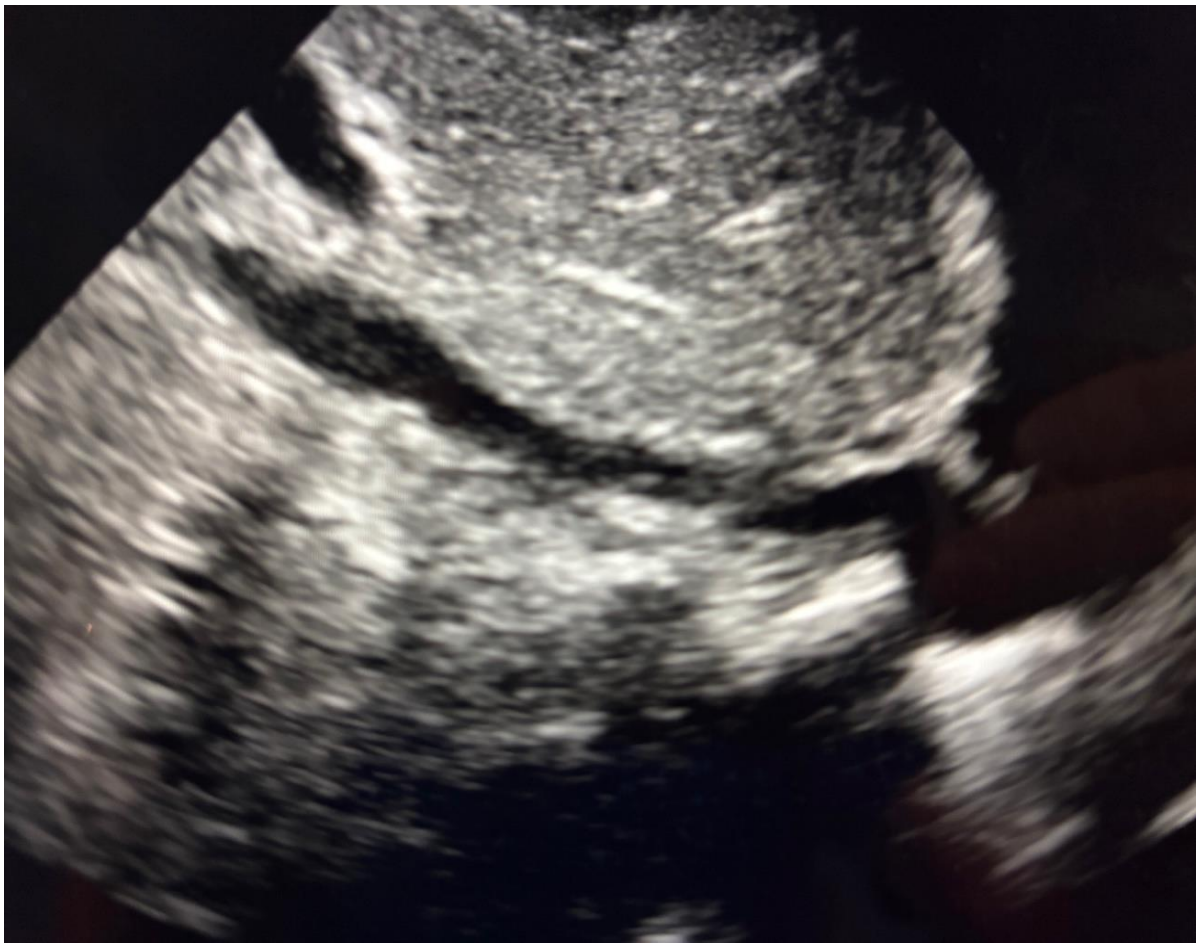
Venous

POCUS has an excellent diagnostic accuracy for acute proximal deep venous thrombosis (DVT) and can be used in an urgent setting.[34] Although DVTs are a common postoperative complication in patients with hip or femur fractures, their incidence is less frequent or unknown in the preoperative period. Nevertheless, a DVT can occur soon after injury, being a life-threatening condition. High-frequency linear probe in venous preset is used. The "2-point" POCUS technique evaluates the common femoral and the popliteal vein, while the "3-point" technique includes the femoral vein. In very simple terms, a DVT is diagnosed when the veins do not completely collapse under compression with the US probe and an echogenic thrombus is identified in the lumen of one of these veins. In patients with hip or femur fractures, leg positioning ("frog leg") to assess the popliteal vein can be challenging due to pain. Studies found that both 2 or 3-point compression tests have a high sensitivity and specificity.[34]

Venous excess ultrasound (VExUS) is a technique that can be used pre- and/or postoperatively to assesses blood flow and volume status in the central veins to help guide fluid management. In this situation, low-frequency curvilinear probe is used. Doppler flow quantifies systemic congestion by assessing the inferior vena cava (IVC), hepatic, and portal veins. A detailed explanation of this method is beyond the scope of this paper, but in simple terms, the goal is to identify any degree of venous congestion. A grade 0 score (IVC < 2cm) indicates that venous congestion is not present. (Figure 7) Grades 1 to 3 represent increasing severity of congestion. In these circumstances, fluid administration should be judicious. (Figure 8) It is important to consider these findings in association with other bedside information.[35, 36]

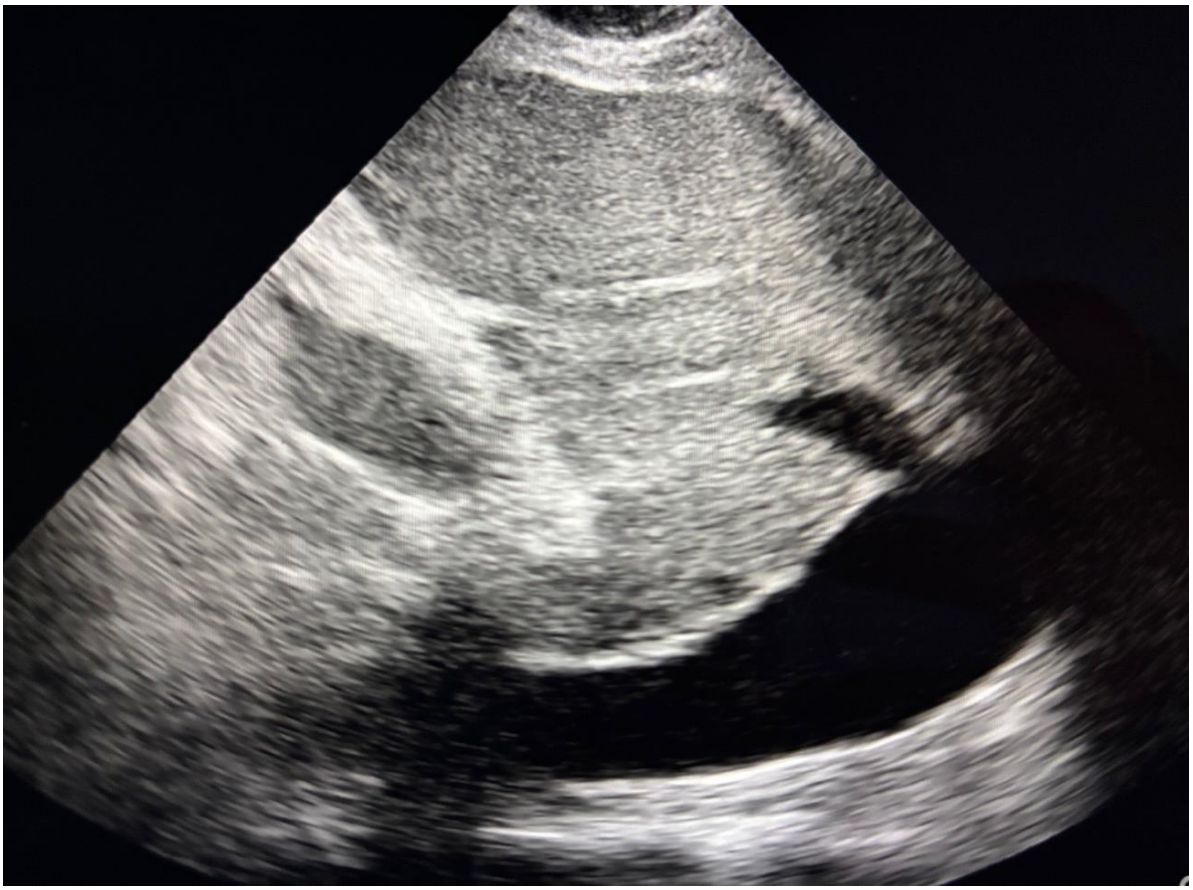
Bladder

Bladder ultrasound (low-frequency curvilinear probe) is a quick, easy, and noninvasive way to assess bladder emptying. It can prevent unnecessary bladder catheterization, diagnose urinary retention, and help identify correct Foley catheter positioning. This can be very helpful in patients with hip or femur fractures, where urinary retention is a common complication both pre- and postoperatively. Furthermore, bladder distention can exacerbate pain, elevate blood pressure, and agitation.[6-9]



Inferior Vena Cana < 2cm

Figure 7: Inferior Vena Cava US



Inferior Vena Cava > 2cm

Figure 8: Inferior Vena Cava US

Cardiac

Arguably, the most useful modality of POCUS in patients with hip and femur fractures is the cardiac exam. Helpful information can be quickly obtained to guide anesthestic management. Key findings include: biventricular function, gross valvular abnormalities, pericardial effusion, and an assessment of volume status .[6-9] Using the phased array probe, four main views are used to assess the heart: parasternal long axis, parasternal short axis, apical four-chamber and subxiphoid.

The preoperative cardiovascular risk assessment helps to estimate the likelihood of perioperative adverse outcomes and determine anesthetic management. Functional capacity (FC) is an important predictor of the risk of adverse cardiovascular events after any non cardiac surgery. It is usually measured in task metabolic equivalents (METs), with 4 METs considered the threshold for poor functional capacity. For example, FC is commonly assessed by asking patients if they can climb 2 flights of stairs or perform some activities of daily living (ADLs). Functional capacity evaluation in the elderly can be challenging due to a number of factors. Vision and hearing impairment can prevent patients from performing several activities. Dementia can also impose severe limitations. Pain can lead to decreased mobility. Adverse effects of medications can also contribute to difficult FC evaluation. In addition to a comprehensive clinical history, recent diagnostic tests should be evaluated.[37]

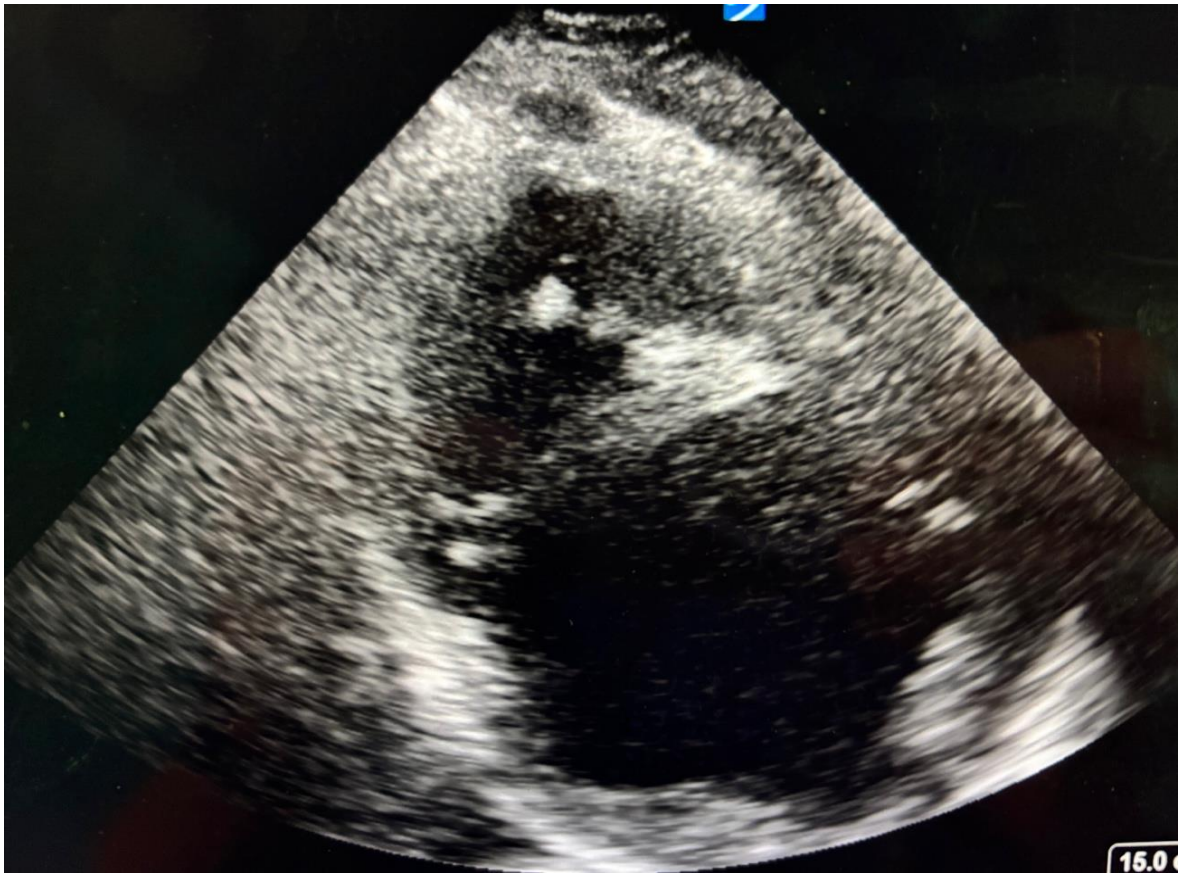
In patients with low or indeterminate FC, the American Heart Association guidelines for non cardiac surgery suggests that investigation with biomarkers (i.e. BNP), echocardiogram and stress testing should be considered.[37] However, repair of hip and femur fractures requires a level of urgency. It has been shown that early fixation is associated with better outcomes. Advantages of performing the surgery within 24 hours include decreased risk of thromboembolism, pulmonary complications and shorter hospital length of stay. Examples of

clinical situations that can prevent early surgery are hemodynamic instability, acute coronary syndrome, decompensated heart failure, coagulopathy, and intracranial hemorrhage.[3]

Considering that the optimal timing from presentation to surgery is relatively short, it is common that anesthesiologists will encounter patients that do not have recent cardiac diagnostic testing or imaging. Cardiac POCUS provides an invaluable tool. It is noninvasive, performed at the bedside, and can rapidly provide very useful information to the anesthesiologist. It is important to emphasize that cardiac POCUS is a focused exam and is not intended to replace traditional diagnostic tools.

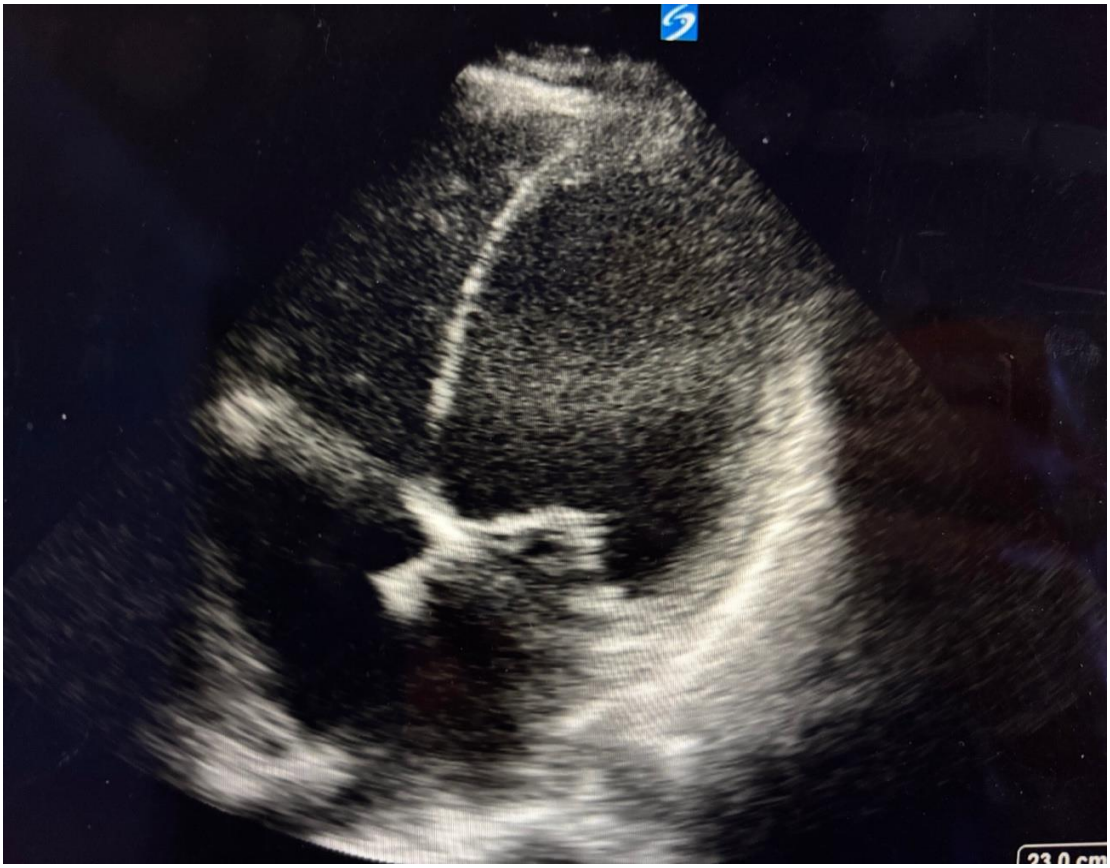
Two key pieces of information that cardiac POCUS can easily provide are the size and systolic function of the ventricles. (Figures 9-11) If one or both ventricles are enlarged, that is usually a sign of a chronic heart condition, and an estimate of systolic function is essential. The right ventricle (RV) should be smaller than the left ventricle (LV), and the apex primarily comprised of the LV. If the RV is enlarged, it will appear to be similar in size as the LV or may contribute to the apex. A rough estimation of systolic function of both ventricles is relevant for the clinician. In the presence of decreased ventricular function, the anesthesiologist can opt for intra arterial blood pressure monitoring and/or the addition of vasoactive medications to support contractility and blood pressure.[6-9]

Gross assessment of the mitral and aortic valves can be performed to determine the presence of stenosis or regurgitation. Moderate to severe valve stenosis can impose serious difficulties in patient management. (Figures 12 and 13) Being aware of these conditions is critical. For example, patients with mitral stenosis do not tolerate tachycardia and fluid overload while aortic stenosis patients may become profoundly hypotensive with the administration of vasodilatory medications. Thus, fluid management and the correct choice of vasopressor is imperative.



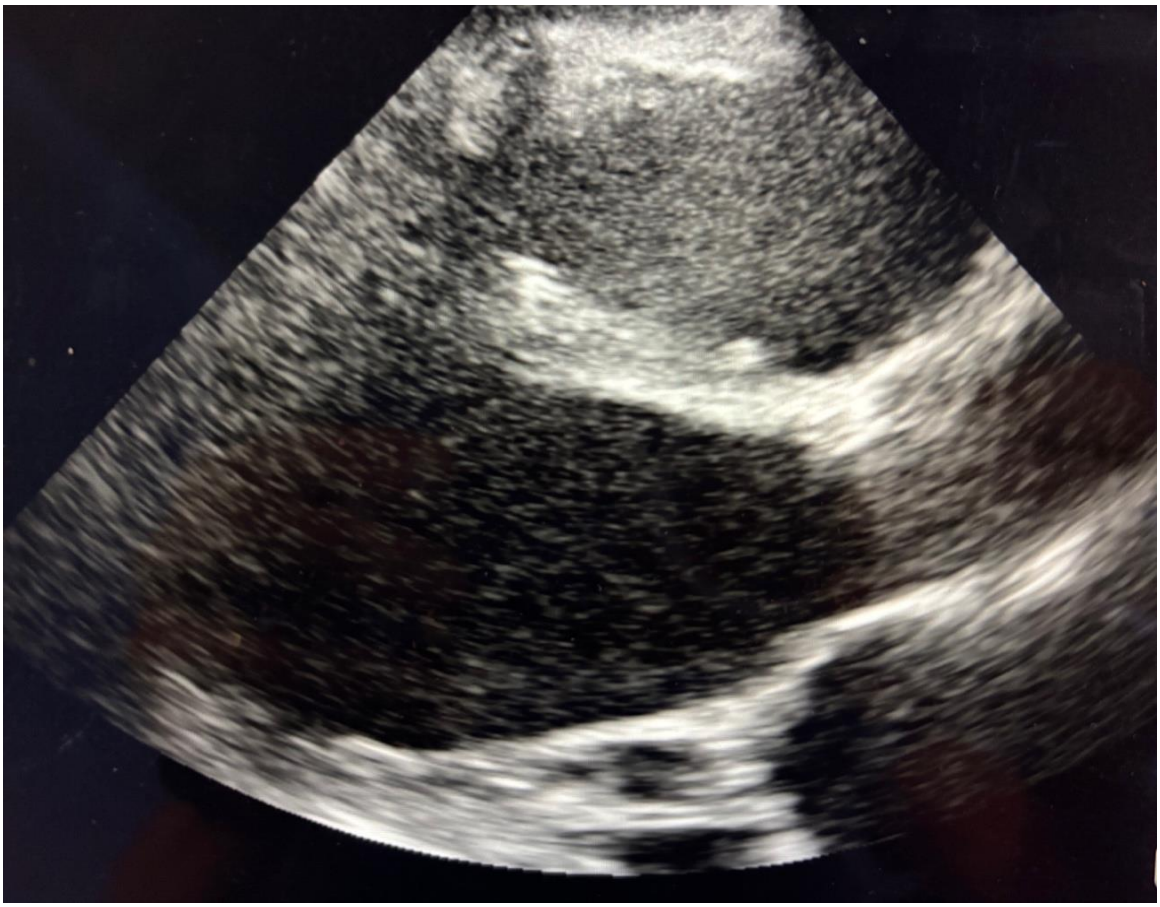
Left ventricular enlargement.

Figure 9: Preoperative cardiac POCUS (Parasternal short-axis view)



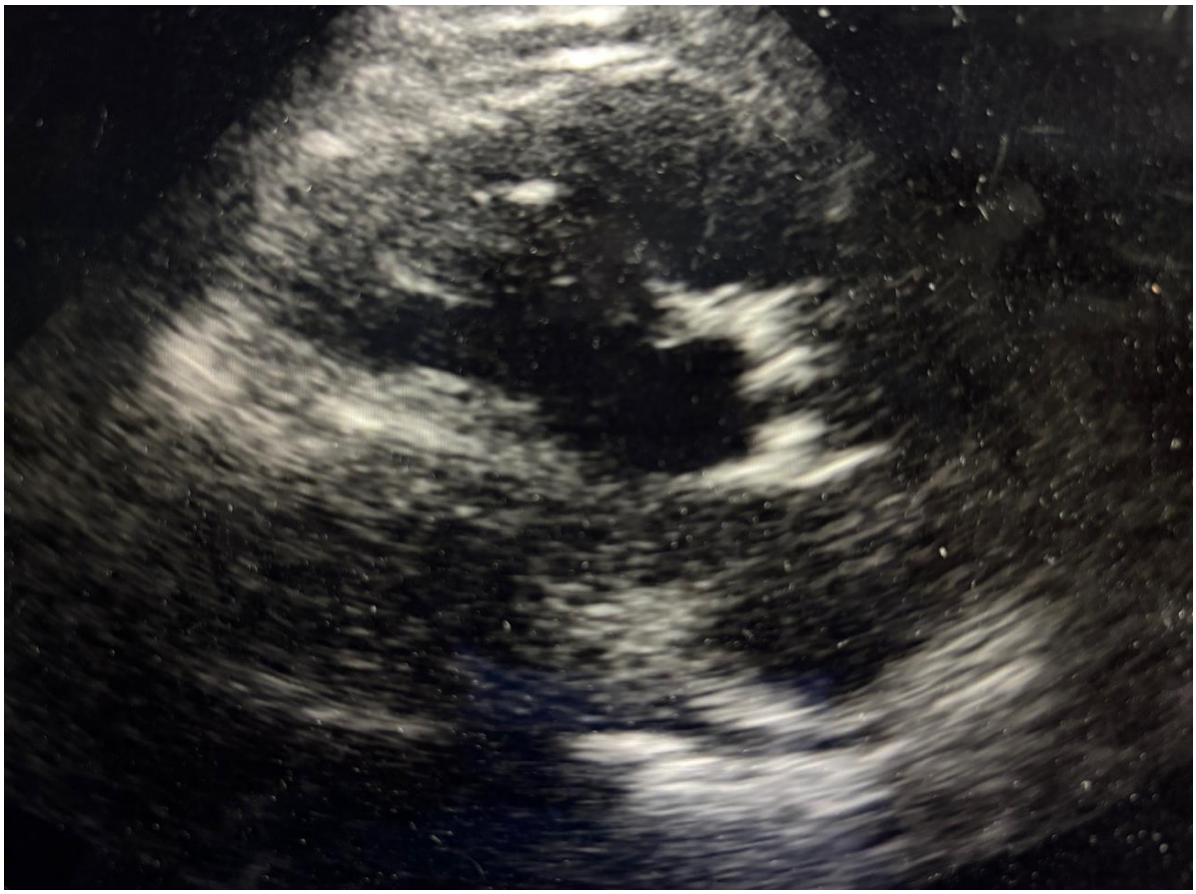
Left ventricular enlargement.

Figure 10: Preoperative cardiac POCUS (Apical 4-chamber view)



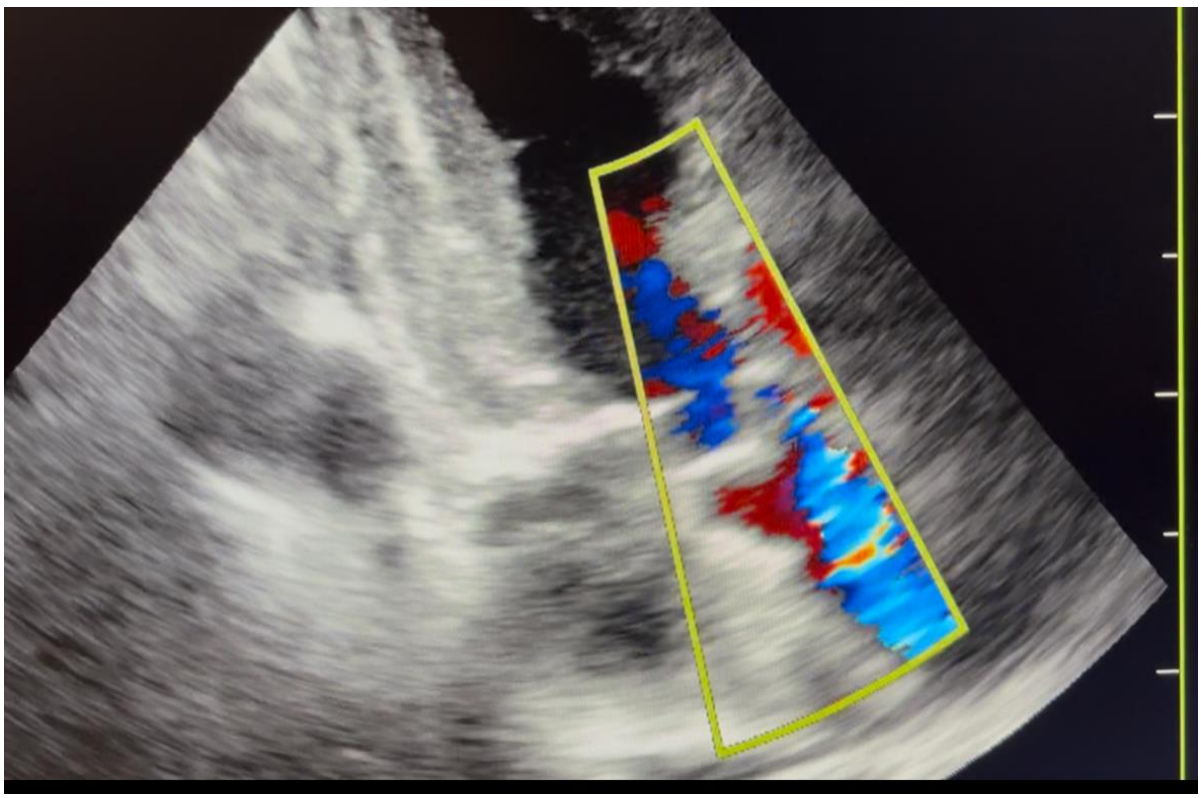
Left ventricular enlargement.

Figure 11: Preoperative cardiac POCUS (Parasternal long-axis view)



Preoperative cardiac POCUS showing aortic valve calcification not previously reported in a patient with femur fracture.

Figure 12: Preoperative cardiac POCUS (Parasternal long-axis view)

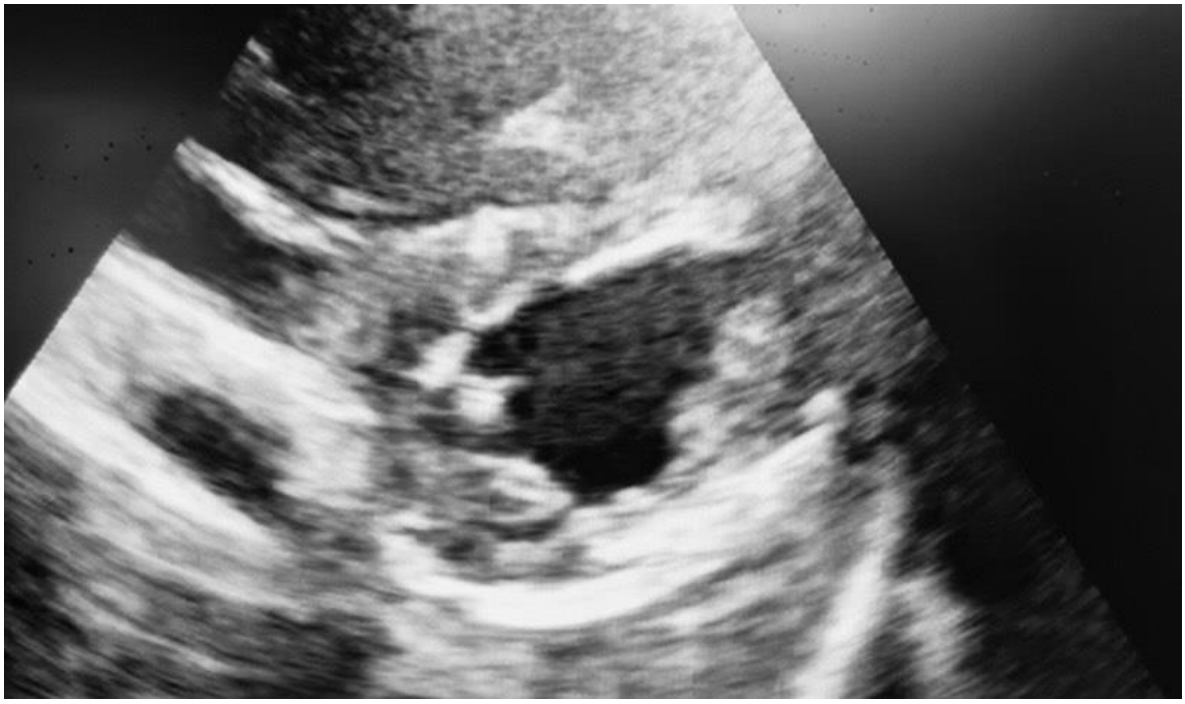


Preoperative cardiac POCUS revealing aortic stenosis not previously reported in a patient with femur fracture.

Figure 13: Preoperative cardiac color POCUS (Apical 3-chamber view)

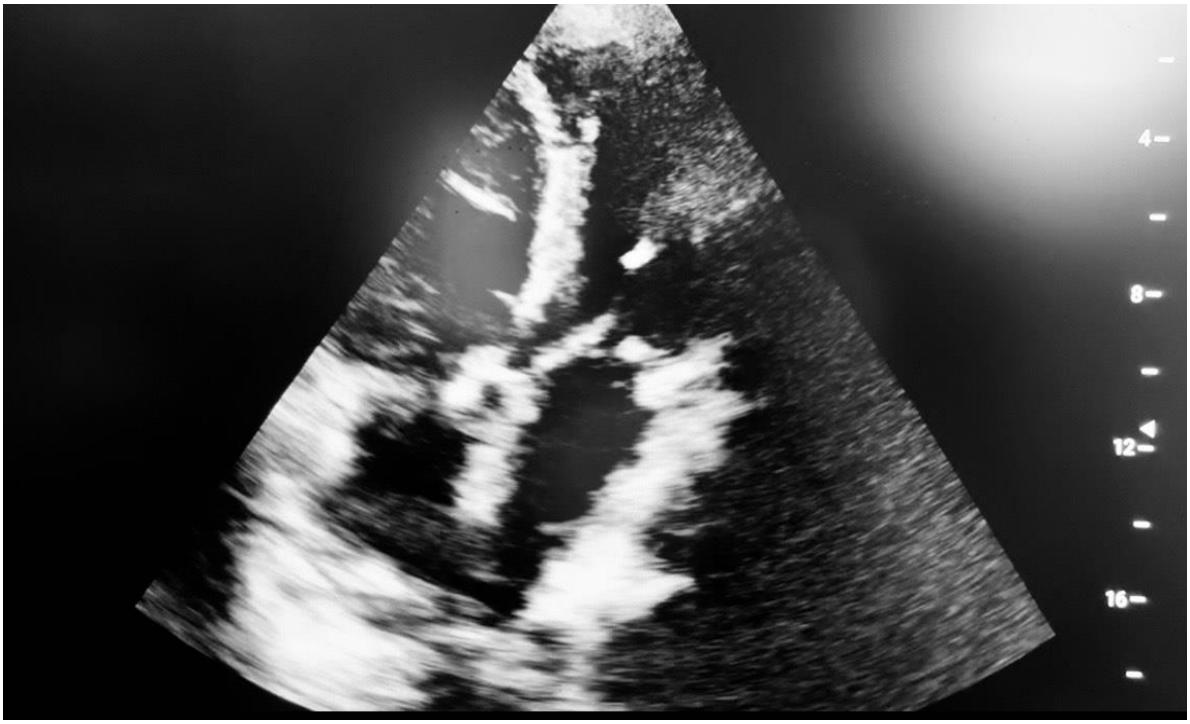
Although a rare condition in the setting of hip and femur fractures, pericardial effusions can be promptly diagnosed by POCUS.[6-9]

Postoperatively, POCUS can be a helpful tool to assess the hypotensive patient, leading to the rapid identification of the cause. A dilated and dysfunctional right ventricle, together with septal flattening and a non-collapsing inferior cava vein are all suggestive of a pulmonary thromboembolism. Interventricular septal flattening, also known as the "D sign", suggests high RV pressure. (Figures 14-15)



Right ventricular enlargement with interventricular septum flattening

Figure 14: Preoperative cardiac POCUS (Parasternal short-axis view)



Right ventricular enlargement

Figure 15: Preoperative cardiac POCUS (Apical 4-chamber view)

A dilated and dysfunctional left ventricle indicates systolic heart failure. An underfilled, hyperkinetic left ventricle, small inferior vena cava diameter, and/or small left ventricular end-diastolic diameter raises the possibility of a low volume status.[6-9]

All those findings guide postoperative management and direct therapies more precisely than the clinical exam alone.

Conclusion

Hip fractures are a frequent and major public health concern for elderly patients. In this high risk population, cardiopulmonary disease may be non-diagnosed or masked by other patient conditions. The preoperative evaluation of patients with hip or femur fractures traditionally involves a limited clinical examination and review of recent studies. However, this is often not enough to provide the anesthesiologist with all necessary information to provide the highest level of care. It has been shown that these patients have a better outcome if surgical repair occurs relatively soon after injury, thus limiting clinicians' ability to complete a comprehensive panel of tests. POCUS has emerged as an effective technique to rapidly provide critically needed information.

From the anesthesia standpoint, significant effort has been made to determine which technique is most beneficial. However, it seems that anesthetic technique has less impact on outcome than the timing of surgery. Preoperative POCUS can be very helpful to provide important information to guide monitoring, anesthetic technique, drug choices, and postoperative care.

Although it has not been clearly demonstrated that POCUS has an impact on patient outcomes, it is reasonable to suppose that POCUS can provide physicians with high yield clinical information that would allow anesthesiologists to individualize management. Hence, having a positive impact on patient care.

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