CARDIAC ARREST ULTRASOUND

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Background

The use of point of care ultrasound (POCUS) is near ubiquitous in US Emergency Departments. It is frequently used in the management of patients in cardiac arrest, most commonly to determine if a patient with a long down time is in cardiac standstill when clinical gestalt does not seem sufficient. However, POCUS can provide not only **prognostic** information, but also important **diagnostic** and **procedural guidance** for these patients.

It is important to have a defined strategy to incorporate insonation into the flow of ACLS care so that interruptions to CPR will be minimized. This handout will describe one method of using ultrasound as an adjunct in the care of the arrested patient.

Learning Objectives

1. understand how to use ultrasound prognostically in cardiac arrest
2. understand how to use ultrasound to guide procedures in cardiac arrest
3. understand how to use ultrasound to narrow the differential diagnosis in cardiac arrest
4. understand how to use an algorithmic approach to efficiently incorporate the use of ultrasound for objectives 1-3 in the management of the patient in cardiac arrest.

Prognosis

The most common current use of ultrasound in cardiac arrest is to assist with determining prognosis. Cardiac standstill seen on ultrasound carries exceedingly poor prognostic value. Most studies have shown no survival when standstill is seen on intraarrest echo (Blaivas, Salen). Of those few cases where patients survived their arrest, none survived to discharge.

Using either your curvilinear or phased array probe, image the heart from the subxyphoid position during a rhythm check. If there is no regular cardiac activity, the patient is in standstill. Note that occasional movements of the valves may be seen due to fluid movement within the vasculature, but there should be no myocardial contractions.

Standstill can be documented as a video clip. Or with M-mode through the still heart as seen in Figure 3. When I am confident that the patient is in standstill, I record a longer clip 30-60 seconds rather than the 6 second clips that our machine is preset to record.

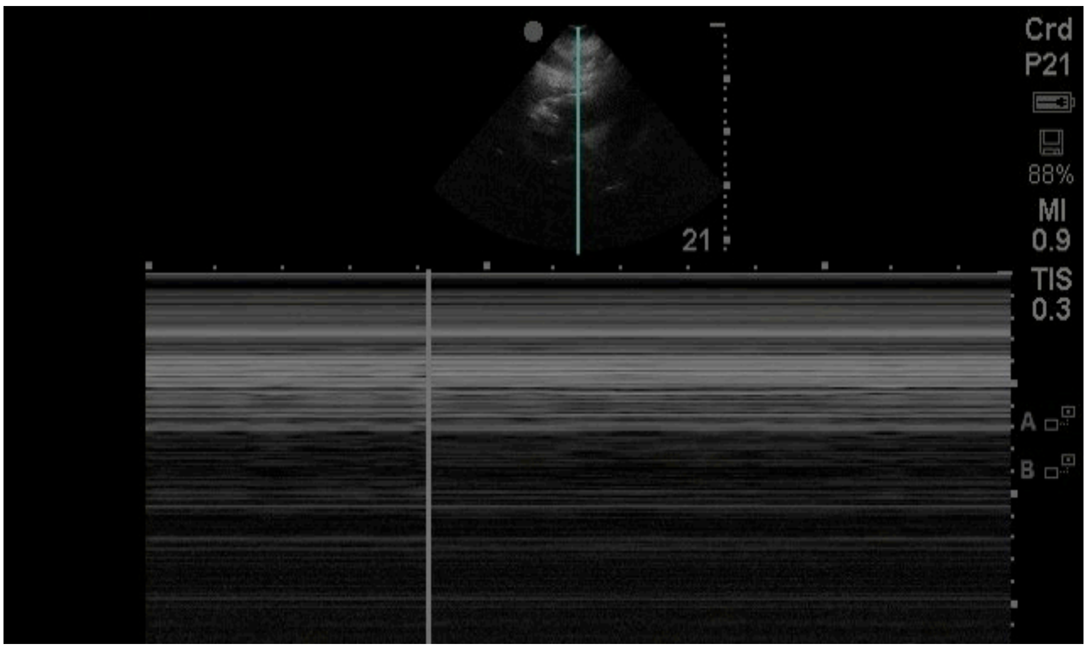


Figure 3. Cardiac Standstill on M-Mode

Procedures

The next most common use of ultrasound in arrest is procedural guidance.

Access

Central – Crash lines are fraught with difficulty. The subclavian veins are frequently chosen over femoral or IJ veins because they are of fixed size. Although it is possible to place a SCV line with ongoing CPR, it is not optimal. The femoral veins are collapsed in the patient with no blood pressure, but ultrasound allows us to overcome this difficulty. As the sonographer scanning from a position at the patient's right hip, it is a simple matter to assist with placement of a femoral vein line – either by two person technique or by placing the line yourself.

Intraosseous – the same position at the patient's right hip facilitates the confirmation of IO line placement using Doppler. Once the line is placed, simply image the bone below the needle as seen in Figure 4. Put the Doppler box over the shadowing area below the bone's cortex and inject a saline flush into the IO catheter. If the needle is placed correctly, you will see a blush of Doppler signal within the bone.

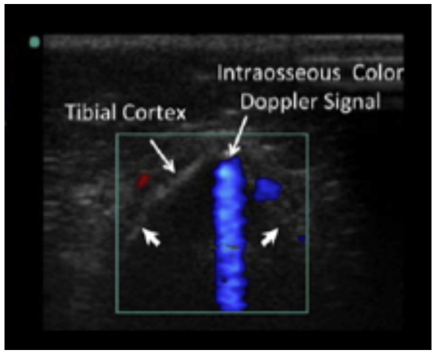


Figure 4 – Confirming IO placement with doppler

Pericardiocentesis
When pericardial effusion is noted during an arrest, pericardiocentesis should be performed. Ultrasound can be used to guide the procedure.

Real time guidance – Traditionally the subxyphoid approach has been used. Frequently this approach passes through interposed liver, diaphragm and lung. Complication rates as high as 50% have been recorded. With real time guidance, any approach that can be dynamically visualized with ultrasound can be used.

Confirmation of pericardial space access – In addition to selecting an approach, ultrasound can be used to confirm that the needle tip is in the pericardial space. Image the pericardial effusion from a static position such as the apical view, while the pericardiocentesis needle is advanced. Once return of fluid is noted in the syringe, a small amount of saline or pericardial fluid that has been withdrawn is reinjected. The ultrasound should show swirling fluid and microbubbles in the pericardial space if the needle is correctly positioned. If bubbles are seen in the right ventricle, the needle has been advanced too far, and the operator knows to withdraw until they are in the pericardial space.

Intubation

Trachea – the TRUE exam and others have documented that the endotracheal tube can reliably be identified within the trachea.

Esophagus – If two people are performing the intubation once can image the esophagus while the intubation is in process. If the esophagus dilates, you are aware that the tube is malpositioned before you have to check breath sounds or end tidal CO_2.

Lung Sliding – after confirmation of ETT placement with esophageal imaging, and $EtCO_2$, we can image the pleura to see whether the endotracheal tube is positioned correctly. If a right mainstem intubation was performed, there will be an absence of lung sliding on the contralateral side. In this case lung pulse – pleural sliding at the rate of the patient's heartbeat may be observed.

Diagnosis

Few Emergency Physicians are currently using ultrasound during the management of cardiac arrest in a diagnostic fashion, but this is the good stuff. It is exceedingly frustrating to be managing a younger patient in arrest and you aren't quite sure why they arrested. There may be a clue from the history given by EMS, but usually that history has come from distressed family, through harried providers and is subject to data loss and changed bits.

What if there was a way to look into the patient and determine the presence or absence of any of the diagnoses on the broad differential for cardiac arrest? Ultrasound you say? Let's take a look based on presenting rhythm.

VF/pVT – If the patient is in VF or pulseless VT, ultrasound plays a limited role. Occaisionally you will note fine ventricular fibrillation in the patient that is thought to be asystolic. The pre-ultrasound approach to this problem was to treat them per the PEA/asystole algorithm, until nothing was working, then say "well, it might be fine vfib, let's shock em". With ultrasound you may be able to avoid this delay if you can pick up ventricular fibrillation on your first rhythm check. So be sure to look for this. See video of ventricular fibrillation in the notes for this lecture on sinaiem.us.

PEA/Asystole – When your patient is in PEA or asystole, ultrasound has far greater diagnostic utility. PEA/Asystole arrests have a much broader differential than VF/VT, and many of the causes of PEA/Asystole can be uncovered by ultrasound.

Hs	Ts
Hypovolemia	**Tension Pneumothorax**
Hypoxia	**Tamponade (Cardiac)**

H+ Ion (Acidosis)	Toxins
Hypo/Hyperkalemia	**Thrombosis (PE)**
Hypothermia	Thrombosis (ACS)

Table 1. Differential Diagnosis of PEA/Asystole. The "H"s and "T"s. Ultrasound definable etiologies are bolded.

How do we investigate for these etiologies of arrest using ultrasound?

Hypovolemia: the hypovolemic patient will have an underfilled (<1 cm) or dynamic IVC. In the spontaneously breathing patient, the IVC with decrease in size with each breath, but in cardiac arrest the opposite occurs. In mechanically ventilated patients, an increase in IVC size > 18% is consistent with preload dependence. Don't worry about trying to measure the IVC in arrest, just eyeball it. Any change in size warrants good fluid resuscitation.

If hypovolemia is identified, look for worrisome causes by imaging the abdomen with FAST and aorta exams. Look for hemothorax by extending the RUQ and LUQ fast views into the thorax. All of these studies can be done with ongoing CPR.

Tension Pneumothorax: it is not impossible to evaluate for tension pneumothorax during CPR. If the provider doing compressions is on the opposite side of the patient it is easy to reach up and take a quick look at the pleural lines on both sides of the chest. You need to time this with BVM or ventilator breaths.

Tamponade: the presence of any pericardial effusion during cardiac arrest implicates tamponade as the etiology of arrest. In these cases there will be black fluid seen around the heart and a plethoric IVC.

Thrombosis: evidence of pulmonary embolism (PE) resulting in arrest may be seen on ultrasound performed during resuscitation. If a grossly enlarged RV is seen accompanied by an enlarged IVC, consider the possibility of PE. A caveat is that the drop in cardiac output due to arrest and the infusion of crystalloid during resuscitation may also lead to an RV that is relatively larger than the left ventricle. If suspicion for PE is confirmed with thrombus seen in the femoral vessels, or embolus seen within the heart chambers or pulmonary arteries then thrombolysis should be considered.

Algorithms

Protocols: A number of protocols (listed in Table 2) designed for both cardiac arrest and the intimately related problem of unexplained hypotension have incorporated varying groupings of the studies listed above.

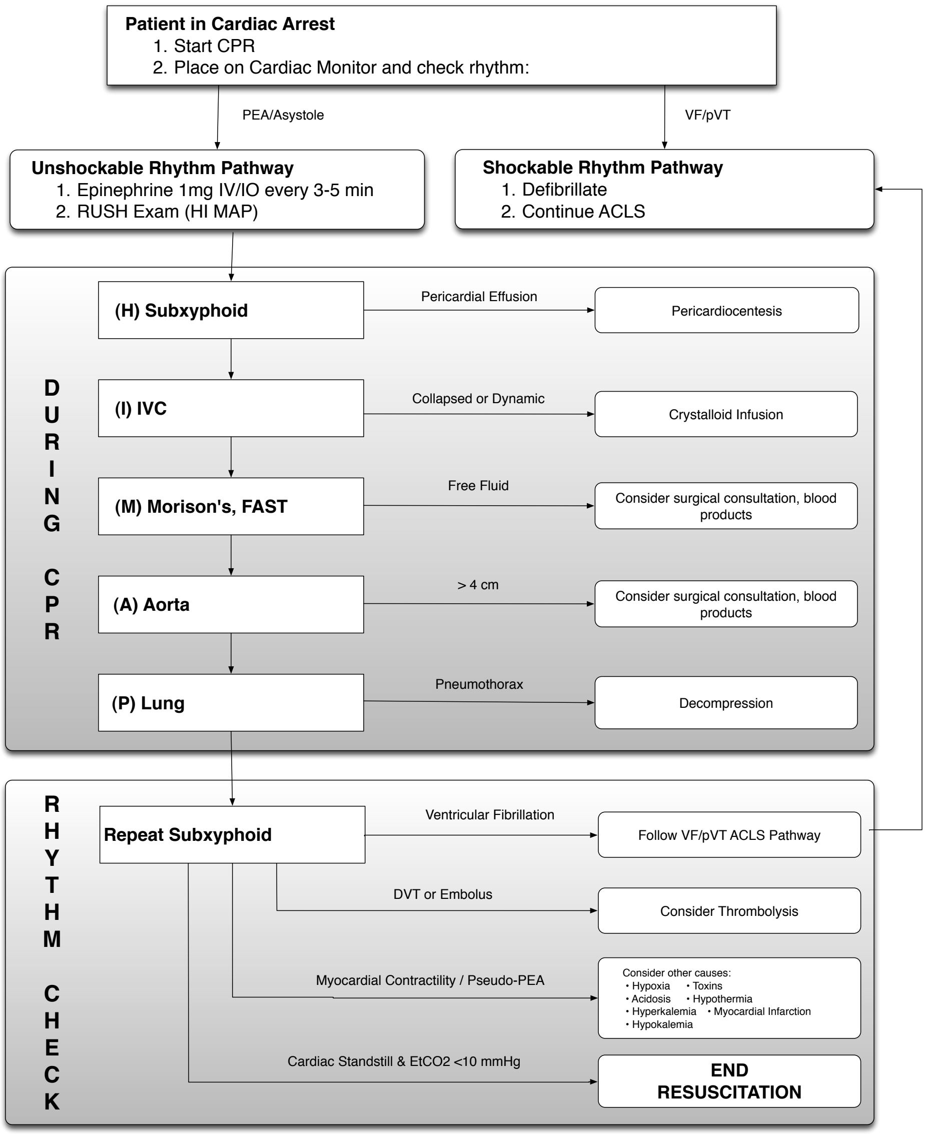
	UHP	AE JONES (UHP+)	TRINITY	FATE	FEER	BLUE	CAUSE	ACES	RUSH (SW)	RUSH (DM)	FEEL	CORE
YEAR	2001	2004	2002	2004	2007	2008	2008	2009	2009	2010	2010	unpub (2010)
WHO	Rose	Jones	Bahner	Jensen	Breitkreutz	Lichtenstein	Hernandez	Atkinson	Weingart	Mandavia	Breitkreutz	Wu
Cardiac	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes
..SX		Yes	AND	AND	AND		OR		AND	AND	AND	
..PSLA		Yes	AND	AND	AND (or PSSA)		OR		AND	AND	AND	
..A4C		Yes		AND	AND		OR		AND	AND	AND	
Lung				Yes		Yes	Yes		Yes	Yes		Yes
FAST	Yes	RUQ, PELVIS	Yes					Yes	Yes	Yes		
Aorta	Yes	Yes	Yes					Yes	Yes	Yes (and suprasternal)		Yes
IVC		Yes						Yes	Yes	Yes		Yes
DVT										Yes		Yes
ETT												Yes

Table 2. Cardiac Arrest and Hypotension US protocols

Of these protocols, the one which includes all of the essential elements and is performable concurrently with the management of a patient in cardiac arrest is the RUSH exam.

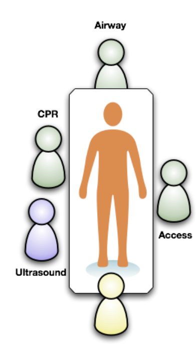
With the current paradigm of minimally interrupted CPR, the views obtained need to be split between **those that can be performed while the patient continues to have effective chest compressions delivered and those that must be done with a still chest** – i.e. during the rhythm or pulse check. The RUSH exam can be tweaked to allow this separation as noted below.

The RUSH exam in Cardiac Arrest Resuscitation



Placement of the Sonographer

In addition to a formal, algorithmic approach to the integration of ultrasound into ACLS, the sonographer and machine need to be considered when designing roles and



positioning of the cardiac arrest team. As in trauma evaluations, when cardiac arrest team members have designated roles and places, resuscitation is run most efficiently. Figure 1. demonstrates the optimal placement of the team member assigned to sonography.

Figure 1. Positions.

Probe Choice

Optimal imaging of the organs and spaces that are viewed during cardiac arrest would require the use of a number of probes of different frequencies and designs.

However, cardiac arrest patients are not ideal imaging subjects. CPR is being done and a flurry of activity surrounds them.

For efficiency, limit yourself to scanning with one multifunctional probe for your cardiac arrest patients. This should be either a large curvilinear or a phased array transducer.

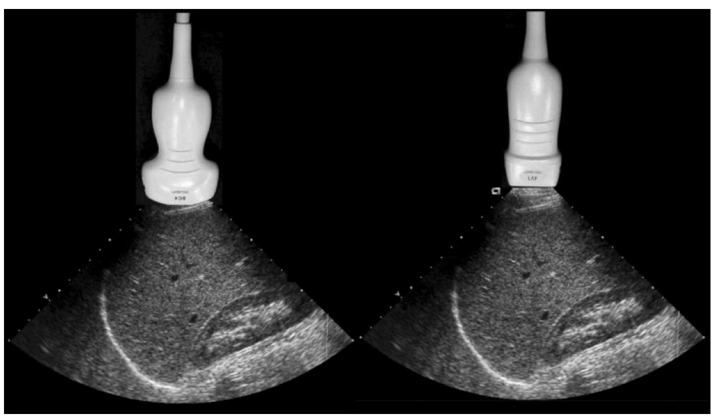


Figure 2. Curvilinear and Phased array transducers

Summary

For your patient in cardiac arrest:

1. Use ultrasound for prognosis, procedural and diagnostic guidance.

2. Choose one multipurpose probe to do the exam.

3. Position the sonographer team member at the patients right hip.

4. Adopt an algorithmic approach to incorporate the use of ultrasound into your current practice.

5. Patients with cardiac standstill are unlikely to survive intact.

6. Patients with pseudo-PEA require more aggressive resuscitation.

7. Use ultrasound to guide line placement and pericardiocentesis, to confirm proper IO placement and as an adjunct to confirm chest tube and ETT placement.

8. Use ultrasound to search for diagnostic evidence of cardiac tamponade, pneumothorax, hypovolemia, hemorrhage (hemothorax, hemoperitoneum), aortic aneurysm, pulmonary embolism, and ventricular fibrillation.

9. Dichotomize your diagnostic search into those views that can be reliably obtained while CPR is ongoing and those that require a still patient.

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