Usefulness of ultrasound during CPR

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▶AHA ACLS 2015 recommendation

Ultrasound During Cardiac ArrestALS 658

Bedside cardiac and noncardiac ultrasound are frequently used as diagnostic and prognostic tools for critically ill patients.[44] Ultrasound may be applied to patients receiving CPR to help assess myocardial contractility and to help identify potentially treatable causes of cardiac arrest such as hypovolemia, pneumothorax, pulmonary thromboembolism, or pericardial tamponade.[45] However, it is unclear whether important clinical outcomes are affected by the routine use of ultrasound among patient

2015 E One lin specific diac ar use du cal acti ROSC

2015 Recommendations—Updated

Continuous waveform capnography is recommended in addition to clinical assessment as the most reliable method of confirming and monitoring correct placement of an ETT (Class I, LOE C-LD).

If continuous waveform capnometry is not available, a nonwaveform CO_2 detector, esophageal detector device, or ultrasound used by an experienced operator is a reasonable alternative (Class IIa, LOE C-LD).

2015 Recommendations—Updated

Ultrasound (cardiac or noncardiac) may be considered during the management of cardiac arrest, although its usefulness has not been well established (Class IIb, LOE C-EO).

If a qualified sonographer is present and use of ultrasound does not interfere with the standard cardiac arrest treatment protocol, then ultrasound may be considered as an adjunct to standard patient evaluation (Class IIb, LOE C-EO).

- **Myocardial contractility**

- **Treatable causes** of cardiac arrest
  - Hypovolemia
  - Pneumothorax
  - Pulmonary embolism
  - Pericardial tamponade

- Confirming placement of **ETT**

* Does not interfere with the **standard cardiac arrest treatment protocol**

Cardiac contractility

▶ Electromechanical dissociation

- Electromechanical dissociation(EMD) in human beings: An echocardiographic evaluation

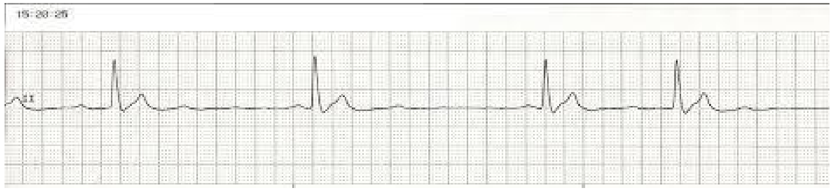
Electromechanical dissociation
n = 22

US evaluation

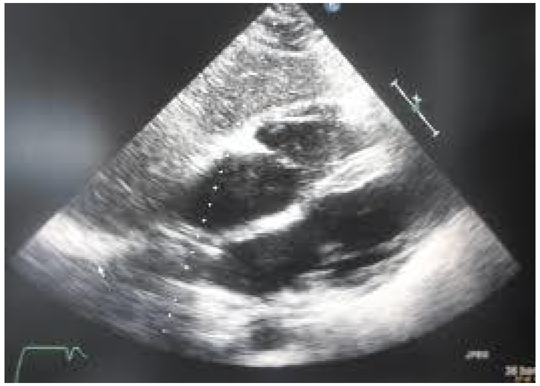
Synchronous myocardial wall motion
n = 19

Valvular motion
n = 15

Visible valve closure
n = 4



No palpable pulse



the term "**electromechanical dissociation**" may be a **misnomer**

▶ Myocardial contractility

Outcome in Cardiac Arrest Patients Found to Have Cardiac Standstill on the Bedside Emergency Department Echocardiogram

- Single center prospective observational study
- April 1999 ~ November 2000
- 169 cardiac arrest pts in ED
- Electrocardiographic Rhythm versus Initial Echocardiographic Finding
  - Cardiac standstill vs Mechanical contraction
  - Asystole 65 (38%) 65 (38%) vs 0 (0%)
  - PEA 38 (23%) 20 (12%) vs 18 (11%)
  - Vf 66 (39%) 51 (30%) vs 15 (9%)

TABLE 2. Survival to Leave the Emergency Department for Patients Based on Initial Rhythm and Echocardiographic Findings*

	Electrocardiographic Asystole & Sandstill	PEA & Standstill	PEA & Contractions	VF & Standstill	VF & Contractions
Survived	0	0	12 (67%)	0	8 (53%)
Died	65 (100%)	20 (100%)	6 (33%)	51 (100%)	7 (47%)

*Standstill = sonographic asystole; PEA = pulseless electrical activity; contractions = mechanical contractions on echocardiogram; VF = ventricular fibrillation.

Cardiac standstill - Positive predictive value for death: 100%

Acad Emerg med 2001; 8:611-621

▶ Myocardial contractility

Does the presence or absence of sonographically identified cardiac activity predict resuscitation outcomes of cardiac arrest patients?

- Prospective multicenter trial (4 academic EDs)
- 12 month period
- 70 cardiac arrest pts in ED
  - Asystole 36 (36/0)
  - PEA 34 (23/11)

Table 1

	+ Sonographic cardiac activity	+ Sonographic cardiac activity	− Sonographic cardiac activity	− Sonographic cardiac activity
Rhythm	PEA	Asystole	PEA	Asystole
ROSC +	8[a]	0	0	0
ROSC −	3	0	23	36

[a] Only 1 of 8 survived to hospital discharge with scores of 1 on the Glasgow-Pittsburgh Cerebral Performance scale (good cerebral performance) and 1 in the Overall Performance category (capable of normal life) [9].

Cardiac standstill - Positive predictive value for death: 100%

▶ Myocardial contractility

Echocardiographic observations during in-hospital cardiopulmonary resuscitation

- 20 **in-hospital** cardiac arrest Pt.
- Mechanical asystole 18
  - Return of ventricular contraction 4 (2-8mins)

Pt.	Age (yr)/ Gender	Prearrest Diagnosis	Initial Arrest/ Rhythm	Echo[a] Application	Echo Mode	Echo Findings	Management	Outcome
1	78/M	CHF	Bradyarrhythmia	7 mins	TTE	Mech. asystole ROVC	STD-CPR Dobutamine	S (3 wks)
2	80/M	Shock	Asystole	1 min	TTE	Mech. asystole cardiac tamponade	STD-CPR Pericardial-centisis	NS
3	70/F	Cancer (leukemia)	Asystole	10 mins	TTE	Mech. asystole CEC	STD-CPR CPR termination	NS
4	85/M	Pulmonary disease	Asystole	10 mins	TTE	Mech. asystole CEC	STD-CPR CPR termination	NS
5	93/M	CHF	VF	1 min	TTE	Mech. asystole CEC	STD-CPR CPR termination	NS
6	74/F	Sepsis	Asystole	3 mins	TTE	Mech. asystole CEC	STD-CPR	NS
7	80/F	CHF	Asystole	1 min	TTE	Mech. asystole CEC	STD-CPR CPR termination	NS
8	76/F	CHF	Bradyarrhythmia	1 min	TTE	Mech. asystole CEC	STD-CPR CPR termination	NS
9	80/M	CHF	VF	15 secs	TTE	Mech. asystole ROVC	STD-CPR Dobutamine	SHD
10	75/M	CHF	Asystole	5 mins	TTE	Mech. asystole CEC	STD-CPR	NS
11	78/M	Sepsis	Asystole	2 mins	TTE	Mech. asystole CEC	STD-CPR CPR termination	NS
12	82/F	Cancer (gastric)	Asystole	2 mins	TTE	Mech. asystole ROVC	STD-CPR Dobutamine	S (>1 hr)
13	68/M	Acute MI	VF	5 mins	TEE	Mech. asystole CEC	STD-CPR CPR termination	NS
14	72/F	Shock (AAA)	Bradyarrhythmia	5 mins	TEE	Hyper-contractile Left ventricle	Volume replacement	S (>1 hr)
15	70/M	Pulmonary embolism	Bradyarrhythmia	5 mins	TTE	Mech. asystole cardiac tamponade	STD-CPR Open-chest Pericardiocentisis	NS
16	60/M	Acute MI	Bradyarrhythmia	30 secs	TTE	Mech. asystole CEC	STD-CPR CPR termination	NS
17	78/F	Sepsis	Asystole	5 mins	TTE	Mech. asystole ROVC	STD-CPR Dobutamine	S (>1 hr)
18	80/M	Shock (UGIB)	Asystole	4 mins	TEE	Mech. asystole CEC	STD-CPR CPR termination	NS
19	75/M	Sepsis	Asystole	3 mins	TTE	Mech. asystole	STD-CPR	NS
20	65/M	Pulmonary disease	Bradyarrhythmia	8 mins	TEE	Hyper-contractile Left ventricle occluded RPA	IV heparin	SHD

Pt., patient; M, male; CHF, congestive heart failure; Mech. Asystole, mechanical asystole; STD-CPR, standard cardiopulmonary resuscitation; S, survivor; ROVC, return of ventricular contraction; TEE, transesophageal echocardiogram; NS, nonsurvivor; F, female; CEC, coalescent echo contrast; VF, ventricular fibrillation; SHD, survivor to hospital discharge; MI, myocardial infarction; TTE, transthoracic echocardiogram; AAA, abdominal aortic aneurysm; UGIB, upper gastrointestinal bleed; IV, intravenous; RPA, right pulmonary artery.

[a]Time elapsed from cardiopulmonary resuscitation initiation to echo application.

CRITICAL CARE MEDICINE

▶ Myocardial contractility

Focused echocardiographic evaluation in life support and peri-resuscitation of Emergency patients: A prospective trial

- **pre-hospital** emergency setting Prospective study
- Aug 2002 ~ Dec 2007
- 100 cardiac arrest & 104 peri-resuscitation pts

Table 1
Outcome of patients undergoing CPR undergoing ALS-compliant peri-resuscitation echocardiography. FEEL: focused echocardiographic evaluation in life support; PEA: pulseless electrical activity; Pseudo-PEA: electrical activity on surface ECG with cardiac motion detected on echocardiography but no palpable pulse.

Pre-FEEL diagnosis	Post-FEEL diagnosis	Survived to admission	Died on scene
Suspected PEA (*n* = 51)	–	22 (43%)	29 (57%)
	Pseudo-PEA (*n* = 38) (wall motion present)	21/38 (55%)	17/38 (45%)
	True-PEA (*n* = 13) (no wall motion present)	1/13 (8%)	12/13 (92%)
Suspected asystole (*n* = 37)	–	13/37 (35%)	24/37 (65%)
	Wall motion present (*n* = 13)	9/37 (24%)	4/37 (11%)
	No wall motion present (*n* = 24)	4/37 (11%)	20/37 (54%)
Pooled suspected PEA and asystole (*n* = 88)	–	35/88 (40%)	53/88 (60%)
	Wall motion present	30 (34%)	21 (24%)
	No wall motion present	5 (6%)	32 (36%)

▶ Myocardial contractility

Can serial focussed echocardiographic evaluation in life support (FEEL) predict resuscitation outcome or termination of resuscitation (TOR)? A pilot study

- Single center prospective observational study
- Nov 2013 ~ Apr 2015
- 48 Non traumatic **OHCA** pts in ED

Table 3
Serial echocardiographic cardiac standstill duration for predicting non-ROSC.

Cardiac standstill duration	6 min		8 min		10 min		12 min	
	Yes	No	Yes	No	Yes	No	Yes	No
ROSC, *n*	4	24	1	27	0	28	0	28
Non-ROSC, *n*	20	0	18	2	18	2	16	4
Sensitivity (95% CI)	1.000 (0.832–1.000)		0.900 (0.683–0.988)		0.900 (0.683–0.988)		0.800 (0.563–0.943)	
Specificity (95% CI)	0.857 (0.673–0.960)		0.964 (0.817–0.999)		1.000 (0.877–1.000)		1.000 (0.877–1.000)	
PPV (95% CI)	0.833 (0.626–0.953)		0.947 (0.740–0.999)		1.000 (0.815–1.000)		1.000 (0.794–1.000)	
NPV (95% CI)	1.000 (0.858–1.000)		0.931 (0.772–0.992)		0.933 (0.779–0.992)		0.875 (0.710–0.965)	
AUC of ROC curve	0.991(0.974–1.008)							

ROSC, return of spontaneous circulation; CI, confidence interval; PPV, positive predictive value; NPV, negative predictive value; AUC, area under the curve; ROC, receiver operating characteristic.

Tracheal examination

▶ Tracheal examination

Real-time tracheal ultrasonography confirmation of endotracheal tube placement during cardiopulmonary resuscitation

- Prospective observational study
- Sep 2010 ~ Jun 2012
- 3 senior EM residents with attending Physicians
- 89 CA pts (7 esophageal)

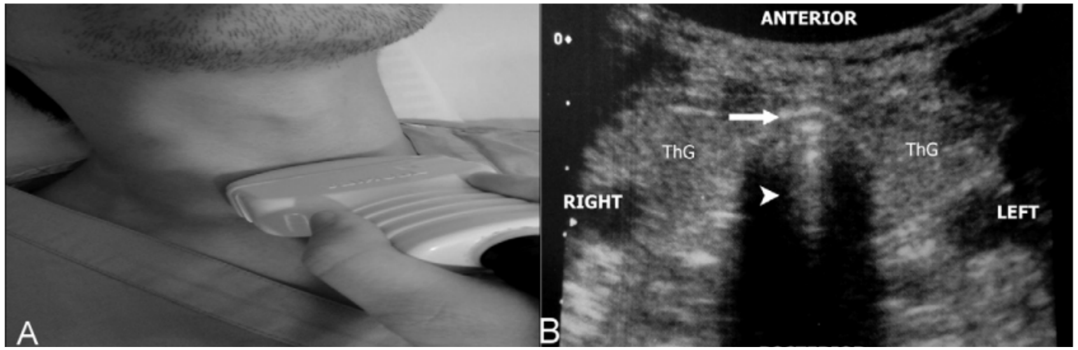


Table 2
Summary of tracheal and esophageal intubation by tracheal ultrasonography.

	Total ($n = 89$)		Sonographer 1 ($n = 37$)		Sonographer 2 ($n = 23$)		Sonographer 3 ($n = 29$)	
	US tracheal	US esophageal	US tracheal	US esophageal	US tracheal	US esophageal	US tracheal	US esophageal
Tracheal intubation, n	82	0	33	0	22	0	27	0
Esophageal intubation, n	1	6	1	3	0	1	0	2

US, ultrasound.

Table 3
Test characteristics for tracheal intubation by sonographers.

	Total ($n = 89$)	Sonographer 1 ($n = 37$)	Sonographer 2 ($n = 23$)	Sonographer 3 ($n = 29$)
Sensitivity, % (95% CI)	100.0 (94.4–100.0)	100.0 (87.0–100.0)	100.0 (81.5–100.0)	100.0 (84.5–100.0)
Specificity, % (95% CI)	85.7 (42.0–99.2)	75.0 (21.9–98.7)	100.0 (5.5–100.0)	100.0 (19.8–100.0)
PPV, % (95% CI)	98.8 (92.5–99.9)	97.1 (82.9–99.8)	100.0 (82.5–100.0)	100.0 (84.5–100.0)
NPV, % (95% CI)	100.0 (54.7–100.0)	100.0 (31.0–100.0)	100.0 (5.5–100.0)	100.0 (19.8–100.0)

PPV, positive predictive value; NPV, negative predictive value; CI, confidence interval.

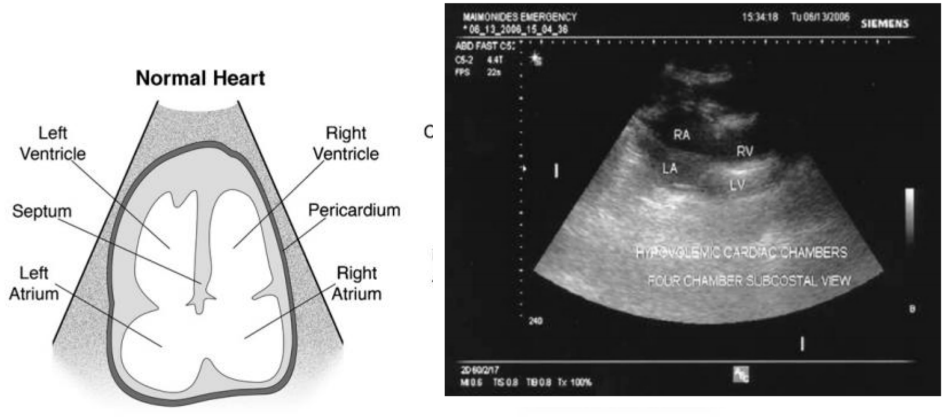
Resuscitation 2013 84:1708-12

POCUS in cardiac arrest

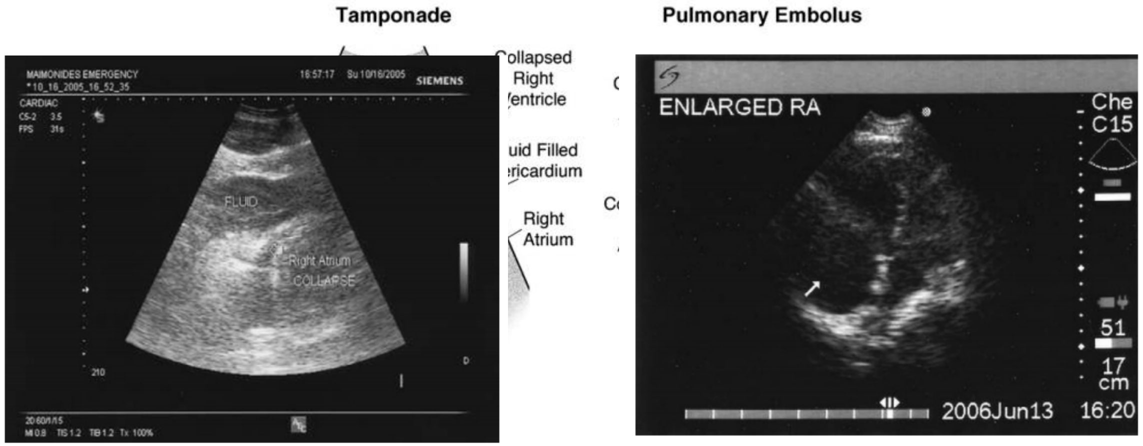
▶ CAUSE protocol

C.A.U.S.E.: Cardiac arrest ultra-sound exam—A better approach to managing patients in primary non-arrhythmogenic cardiac arrest

- **Hypovolemia**
- **Cardiac tamponade**
- **Pulmonary embolus**
- **True asystole(cardiac standstill)**



- Tension pneumothorax



▶ CAUSE protocol

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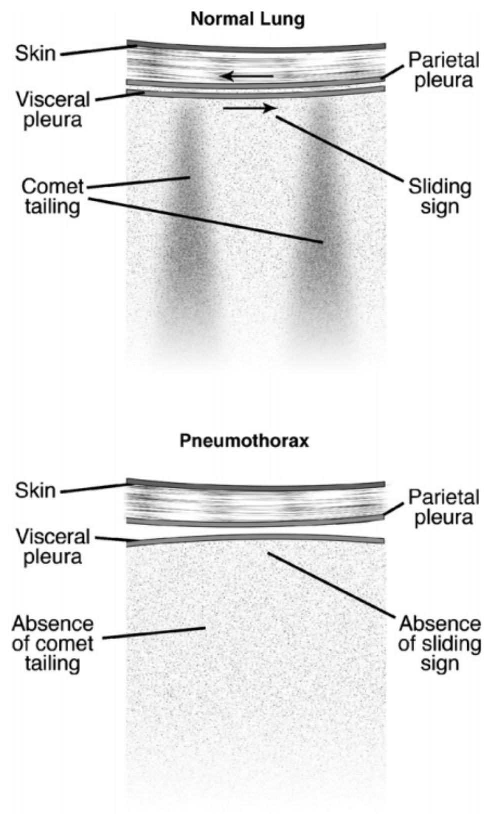

Resuscitation 2008 76:198-206

▶ FEEL protocol

Focused echocardiographic evaluation in resuscitation management: Concept of an advanced life support–conformed algorithm

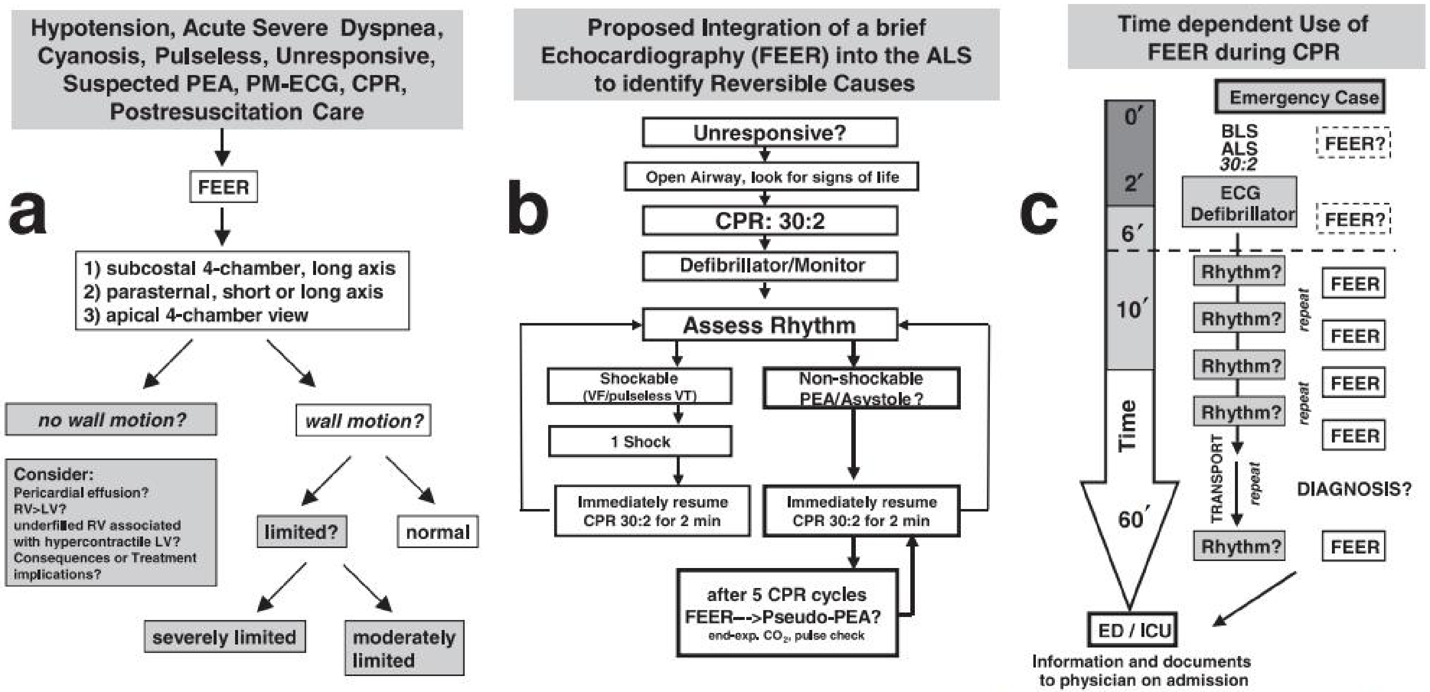

Figure 1. Focused echocardiographic evaluation in resuscitation management (*FEER*) in emergency and critical care medicine. Algorithm with indications and workflow (*a*); integration into advanced life support (*ALS*) (*b*); road map of repeated use of FEER during resuscitation stages (*c*). FEER has to be completed within 5 secs during pauses of cardiopulmonary resuscitation (*CPR*). *PEA*, pulseless electrical activity; *PM-ECG*, pacemaker–electrocardiogram; *RV*, right ventricle; *LV*, left ventricle; *VF/pulseless VT*, ventricular fibrillation/pulseless ventricular tachycardia; *end-exp. CO_2*, end-expiration CO_2; *BLS*, basic life support; *ED/ICU*, emergency department/intensive care unit.

▶ FEEL protocol

Focused echocardiographic evaluation in resuscitation management: Concept of an advanced life support–conformed algorithm

4 phase	10 step
High-quality CPR, preparation, team information	1) Perform BLS and ACLS
	2) Tell the CPR team: "I am preparing an echocardiogram"
	3) Prepare & test ultrasound
	4) Accommodate situation be ready to start
Execution, obtaining the echocardiogram	5) Tell CPR Team to count down 10 secs and to undertake a pulse check
	6) Command: "Interrupt at the end of this cycle for echocardiography"
	7) Put the probe during chest compressions
	8) Perform a subcostal (long axis) echocardiogram as quickly as
Resuming CPR	9) Command after 9 secs at the latest: "Continue CPR" and control it
Interpretation and consequences	10) Communicate the findings to the CPR team

Crit care med 2007 35:150-61

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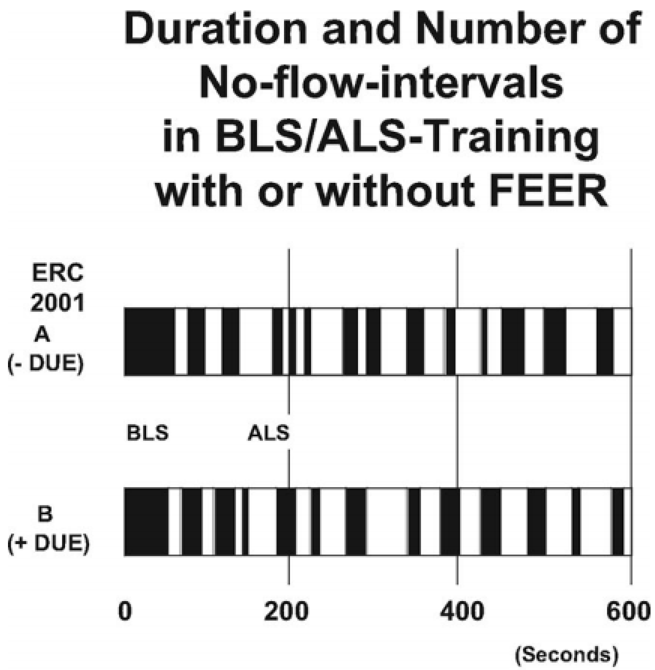
FEEL protocol

Focused echocardiographic evaluation in resuscitation management: Concept of an advanced life support–conformed algorithm

- 18 group, 2-rescure CPR scenario
- Used Dummy echocardiography
- No differences in duration of NFI



▶ FEEL protocol

Focused echocardiographic evaluation in life support and peri-resuscitation of Emergency patients: A prospective trial

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Resuscitation 2010 81:1527-33

▶ FEEL protocol

Focused echocardiographic evaluation in life support and peri-resuscitation of Emergency patients: A prospective trial

- **PEA: 51 pts**
  - Pseudo-PEA: 38 pts
    - Left ventricular failure: 22 pts (59%)
    - **Pericardial tamponade: 5 pts (13%)**

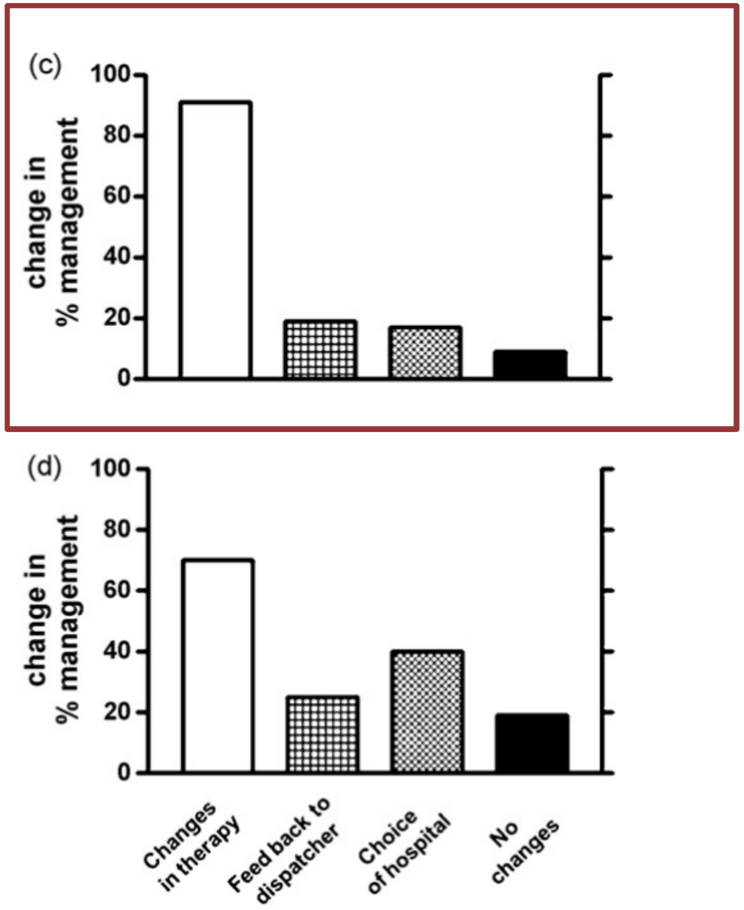
      ROSC after pericardiocentesis: 3 pts (60%)
    - Dilated RV: 4 pts (10.5%)
    - Hypovolemia: 2 pts (5.3%)

- **Asystole 37 pts**
    - Pericardial tamponade: 3pts(8%)

FEEL protocol

Focused echocardiographic evaluation in life support and peri-resuscitation of Emergency patients: A prospective trial

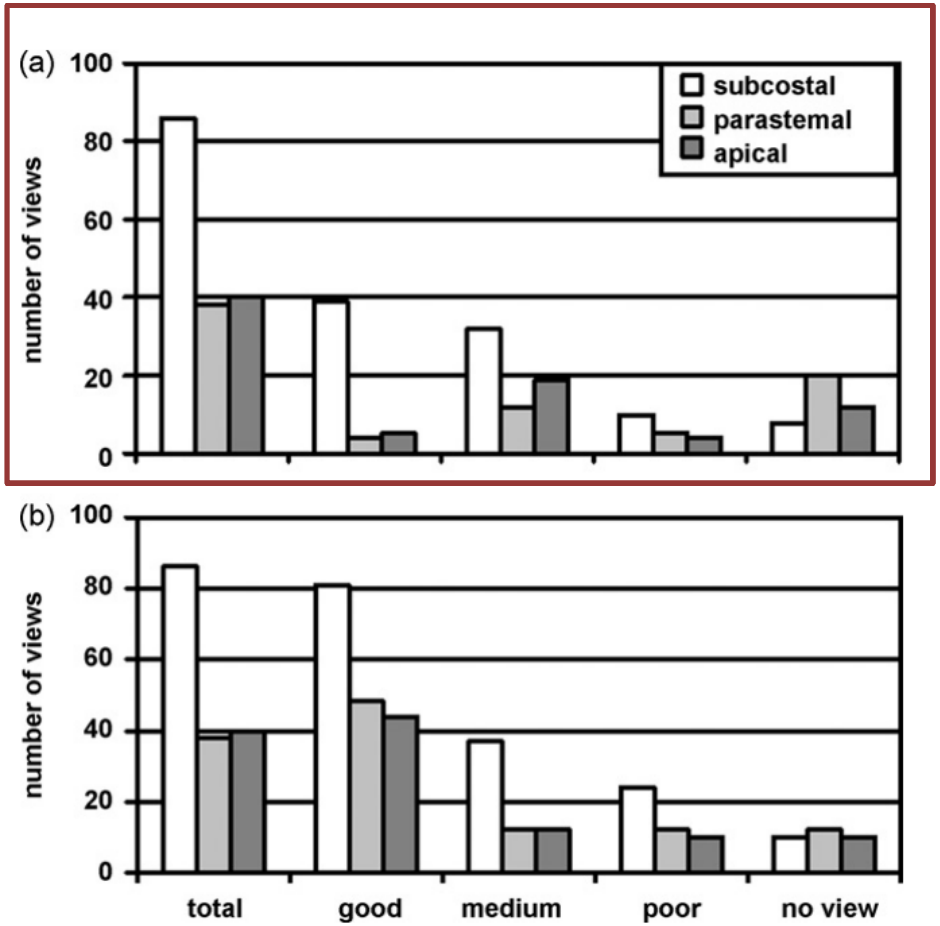
- Integration into ALS management
  - Changes in therapy: 89%



▶ FEEL protocol

Focused echocardiographic evaluation in life support and peri-resuscitation of Emergency patients: A prospective trial

- Imaging quality in CPR



▶ Survival outcome

Echocardiography integrated ACLS protocol versus conventional cardiopulmonary resuscitation in patients with pulseless electrical activity cardiac arrest

- Prospective interventional study
  - Group A (50 PEA pts) : ACLS protocol + POCUS by US trained Eps
  - Group B (50 PEA pts) : conventional ACLS protocol

Table 1. Resuscitation outcome for PEA arrest patients based on the echocardiography findings

	ROSC	Death	Total
Presence of MVA (pseudo PEA)	17 (43%)	22 (57%)	39 (78%)
Absence of MVA (true PEA)	0 (0%)	11 (100%)	11 (22%)
Hypovolemia	4 (36%)	7 (64%)	11 (22%)
Pericardial effusion	2 (29%)	5 (71%)	7 (14%)

- ROSC patient of Group A vs. Group B: 17(34%) vs. 14(28%), p=0.52

There was no significant difference of survival outcome between the two groups

Is POCUS associated prolonged CPR pauses?

▶ CPR pauses

Ultrasound use during cardiopulmonary resuscitation is associated with delays in chest compressions

- Single center prospective study
- Aug 2015 ~ Sep 2016
- Analyze recorded video
- 23 patient, 123 pulse check

Table 2
Mean duration of pulse checks, calculated by treating each pulse check as an independent observation.

Type of pulse check	Mean duration in seconds	95% CI
Without POCUS	13	12–15
With POCUS	21	18–24

Table 3
Effects of intervention on pulse check duration estimated by the mixed-effects model.

Intervention	Mean time (sec)	Standard error (sec)	P-value
POCUS use	8.4	1.6	<0.0001
Procedure performed	2.9	1.7	0.08

▶ CPR pauses

Point-of-care ultrasound use in patients with cardiac arrest is associated prolonged cardiopulmonary resuscitation pauses: A prospective cohort study

- Single center prospective study
- Jul 2016 ~ Jan 2017
- Recorded video analysis
- 24 patient, 110 compression pauses

  - CPR pauses with POCUS 19.3s
  - CPR pauses without POCUS 14.2s

▶ CPR pauses

Point-of-care ultrasound use in patients with cardiac arrest is associated prolonged cardiopulmonary resuscitation pauses: A prospective cohort study

Table 2
Univariable and multivariable linear regression analysis of predictors associated with CPR pause duration.

Predictor variable[b]	Univariable β (sec)	Univariable SE	Univariable p-value	Multivariable[a] β (sec)	Multivariable[a] SE	Multivariable[a] p-value
POCUS performed	5.0	2.1	0.02	6.4	2.2	0.004
Resident year						
PA	REF			REF		
2	4.1	5.4	0.45	4.9	5.4	0.91
3	7.3	5.7	0.21	7.1	6.0	0.24
4	12.8	5.6	0.02	12.3	5.6	0.03
Intubation performed	2.5	3.5	0.49	2.3	3.5	0.51
Automated cardiac compression device	−1.0	2.1	0.64	−0.8	2.3	0.73
Attending ultrasound fellowship trained	−3.9	2.3	0.09	−4.1	2.4	0.09
Same provider performs POCUS and leads code	6.1	2.8	0.04			

POCUS, point-of-care ultrasound; PA, Physician Assistant.
[a] Controlled for POCUS performed, resident year, automated cardiac compression device, and attending ultrasound fellowship training.
[b] Reference is "No" unless otherwise indicated.

New POCUS protocol during CPR

▶New POCUS protocol

The Cardiac Arrest Sonographic Assessment(CASA) exam – A standardized approach to the use of ultrasound in PEA

- 1. Cardiac tamponade: 4-15%
    - Hospital discharge rate: 15.4% vs 1.3%

- 2. Pulmonary embolus: 4.0-7.6%
    - Hospital discharge rates: 6.7% vs 1.3%

- 3. Cardiac activity: cardiac standstill
    - Hospital discharge rate 0.0 -0.6%

- Hypovolemia, tension pneumothorax
    - Excluded in routine exam

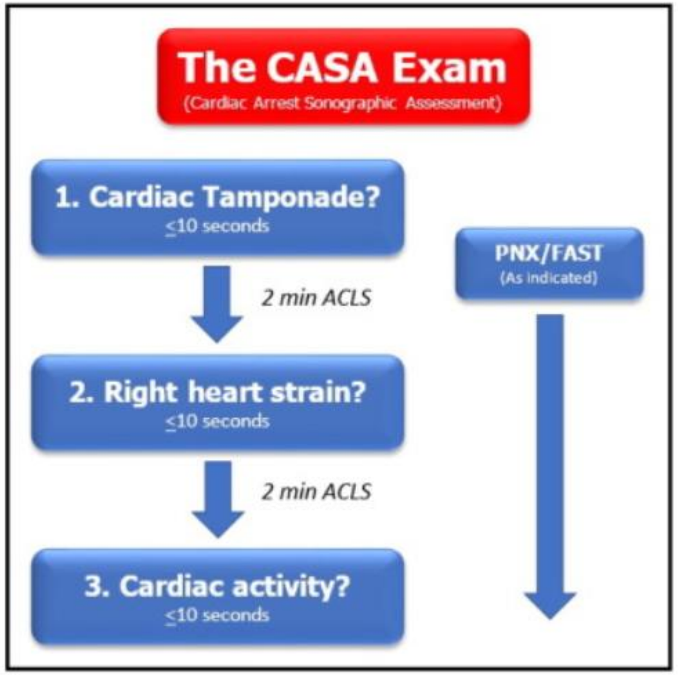


Fig. 1
The Cardiac Arrest Sonographic Assessment (CASA) exam schematic.

▶ New POCUS protocol

Implementation of the Cardiac Arrest Sonographic Assessment (CASA) protocol for patients with cardiac arrest is associated with shorter CPR pulse checks

- Pre and post interventional study
- Intervention on Aug 2017

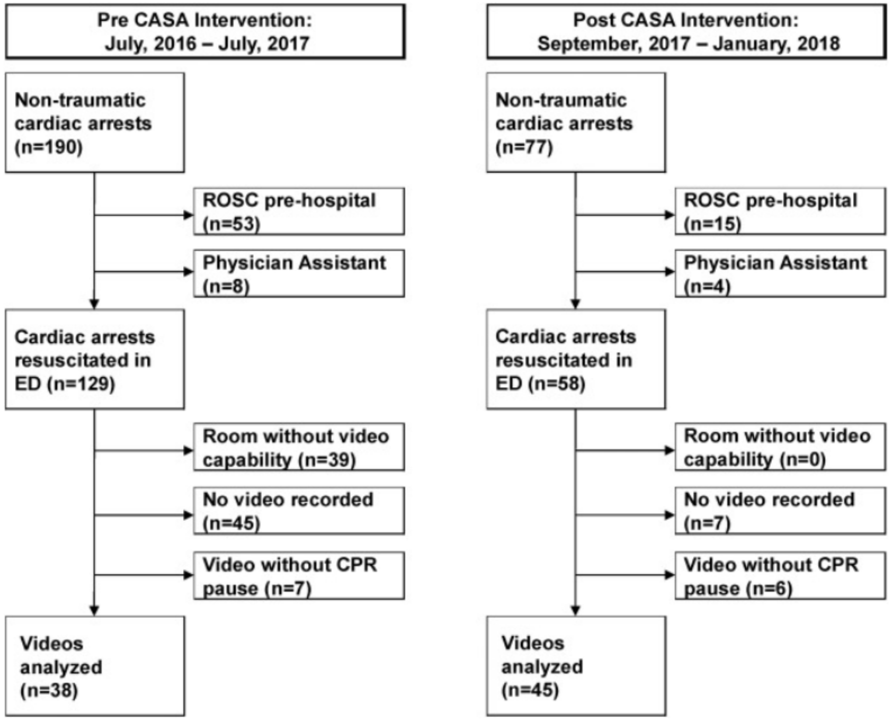


Fig. 1

Consort diagram of participants enrolled in the study.

ROSC: Return of spontaneous circulation.

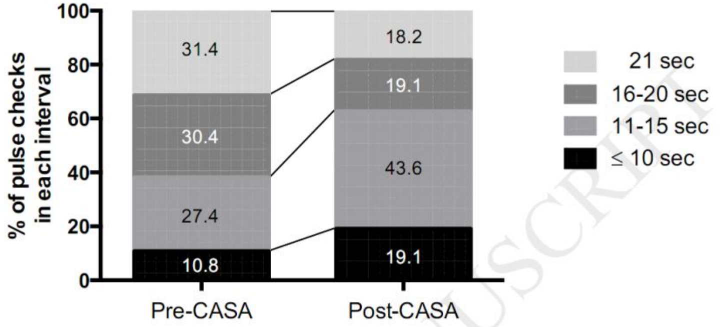
▶New POCUS protocol

Implementation of the Cardiac Arrest Sonographic Assessment (CASA) protocol for patients with cardiac arrest is associated with shorter CPR pulse checks

- CPR pulse check duration

	Pre (sec)	Post (sec)	Difference (sec)	p-value
CPR pulse check pause duration, mean (SE)[a]	18.1 (0.8)	15.1 (0.6)	3.0 (1.0 – 5.0)	0.003
CPR pulse check pause duration with POCUS, mean (SE)[b]	19.8 (1.0)	15.8 (0.7)	4.0 (1.7 – 6.3)	0.0008
CPR pulse check pause duration without POCUS, mean (SE)[c]	15.4 (1.0)	12.8 (0.7)	2.6 (-1.2 – 6.4)	0.18

[a]: pre n=160; post n=140
[b]: pre n=100; post n=110
[c]: pre n=60; post n=30



▶New POCUS protocol

Implementation of the Cardiac Arrest Sonographic Assessment (CASA) protocol for patients with cardiac arrest is associated with shorter CPR pulse checks

Table 3. Multivariable linear regression analysis of predictors associated with CPR pause duration for pulse checks with ultrasound performed.

Predictor variable†	Coefficient (sec)	SE	p-value
Post intervention time period	-3.3	1.2	0.007
Resident year			
2	REF		
3	1.1	1.4	0.45
4	0.2	1.5	0.89
Attending	-3.0	4.0	0.45
Any procedure performed	1.9	1.8	0.28
Attending ultrasound fellowship trained	-3.1	1.3	0.02
Ultrasound on chest before CPR paused	-3.1	1.3	0.01

POCUS, point-of-care ultrasound;
*Controlled for post intervention period, resident year, any procedure performed, and attending ultrasound fellowship training, and placement of ultrasound probe on chest prior to stopping CPR.
†Reference is "No" unless otherwise indicated

ACCEPTED MANUSCRIPT

▶New POCUS protocol

A novel US-CAB protocol for ultrasonographic evaluation during cardiopulmonary resuscitation

- **C**: subcostal view of the heart and inferior vena cava
- **A**: tracheal US
- **B**: bilateral lung sliding sign
    - 4^{th} -5^{th} intercostal space
    - Mid axillary line

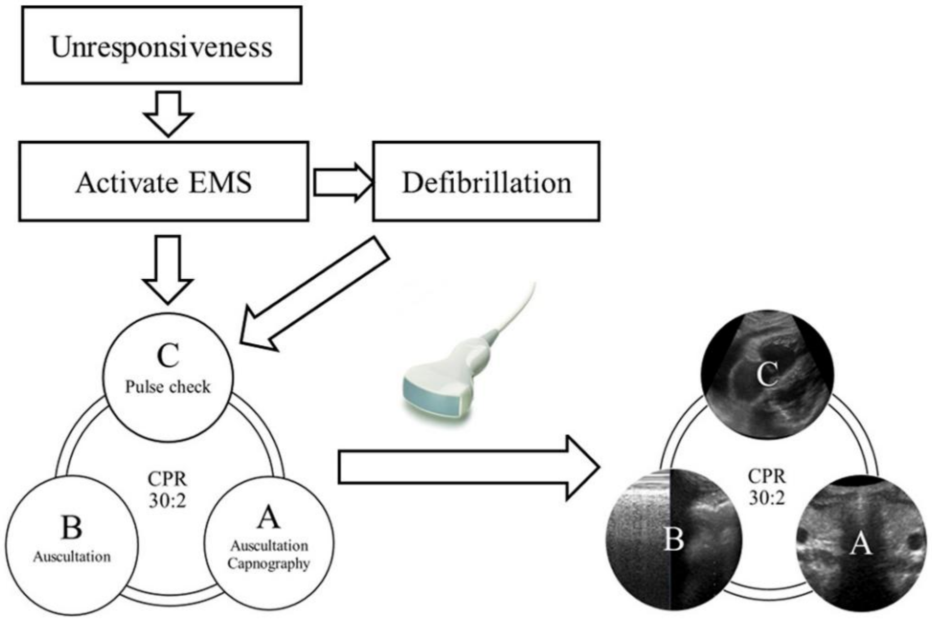


Fig. 1. The US-CAB protocol in an advanced life support (ALS)-compliant manner.

중앙대학교병원 CHUNG-ANG UNIVERSITY HOSPITAL

▶ New POCUS protocol

US-CAB protocol for ultrasonographic evaluation during cardiopulmonary resuscitation: Validation and potential impact

- Single center prospective observational study
- Jan 2016 ~ Mar 2017
- 10 EPs attended 4hr training curriculum
- 177 OHCA pts
    - **Cardiac exam (C):** 9.0 ± 1.4sec
        - Pericardial effusion 9 pts (RV compression 8)
            - Pericardiocentesis: 4pts & ROSC 2 pts (25%)
    - **Airway exam (A):** 7.5 ± 1.5sec
        - Versus capnography ETT confirming time (7.4 vs. 38.3s)
    - **Lung exam (B):** Lt. 8.5 ± 2.0sec / Rt. 7.5 ±1.8sec
        - One lung intubation: 3pts vs. auscultation 2 pts

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▶New POCUS protocol

US-CAB protocol for ultrasonographic evaluation during cardiopulmonary resuscitation: Validation and potential impact

Table 2
Test characteristics for each US-C, A, and B examinations.

	Reference		Sen*, % (95% C.I.*)	Spe*, % (95% C.I.)	PPV*, % (95% C.I.)	NPV*, % (95% C.I.)
US-C	ROSC*	Non-ROSC				
Presence of cardiac activity, n	45	2	62 (50–73)	98 (95–100)	96 (90–100)	78 (71–86)
Absence of cardiac activity, n	28	102				
US-A	Tracheal intubation†	Esophageal intubation				
Sonographic tracheal intubation, n	156	0	100 (100)	100 (100)	100 (100)	100 (100)
Sonographic esophageal intubation, n	0	21				
US-B	Proper ventilation‡	Improper ventilation				
Sonographic proper ventilation, n	174	0	99 (98–100)	100 (100)	100 (100)	67 (13–100)
Sonographic improper ventilation, n	1	2				

* ROSC denotes return of spontaneous circulation; Sen, sensitivity; Spe, specificity; PPV, positive predictive value; NPV, negative predictive value; CI, confidence interval.
† The reference standard is the result of auscultation.
‡ The reference standard is the result of auscultation.

Table 3
Test characteristics of sonographic cardiac activity for return of spontaneous circulation detected at different time points.

Time point	Cardiac activity, n	ROSC*, n	Sensitivity, % (95% C.I.*)	Specificity, % (95% C.I.)	PPV*, % (95% C.I.)	NPV*, % (95% C.I.)
Less than 4 min of CPR* (n = 14)	1	6	0	88 (47–100)	0	54 (25–81)
4–6 min (n = 22)	2	14	7 (0–34)	88 (47–97)	50 (1–99)	35 (15–59)
6–8 min (n = 28)	5	13	38 (14–68)	100 (78–100)	100 (48–100)	65 (43–84)
8–10 min (n = 36)	12	13	92 (64–100)	100 (85–100)	100 (74–100)	96 (79–100)
10–12 min (n = 48)	16	16	100 (79–100)	100 (89–100)	100 (79–100)	100 (89–100)
12–14 min (n = 26)	10	10	100 (69–100)	100 (79–100)	100 (69–100)	100 (79–100)
14–16 min (n = 3)	1	1	100 (3–100)	100 (16–100)	100 (3–100)	100 (16–100)

* ROSC denotes return of spontaneous circulation; PPV, positive predictive value; NPV, negative predictive value; CI, confidence interval; CPR, cardiopulmonary resuscitation.

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▶ What we know

Cardiac standstill is strong prognostic factor for termination of resuscitation, especially **after 10 minutes of ALS**

POCUS can **find treatable causes** and **change the therapy** of cardiac arrest

Further research is needed to determine whether the use of POCUS in cardiac arrest improves **clinical outcomes**