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| Question | |
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| **Population:** | Adults in any setting (in-hospital or out-of-hospital) in non-traumatic cardiac arrest |
| **Intervention:** | A particular finding on point-of-care echocardiography during CPR |
| **Comparison:** | The absence of that finding or a different finding on point-of-care echocardiography during CPR |
| **Main outcomes:** | ROSC, survival to hospital admission, survival to hospital discharge, survival to 180 days, good neurologic outcome at hospital discharge, good neurologic outcome at 180 days |
| **Setting:** | 1. In hospital cardiac arrest 2. Out of hospital cardiac arrest |

# ASSESsment

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| Problem Is the problem a priority? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ● **Yes** ○ Varies ○ Don't know | Historically, physiologic monitoring and feedback to the clinician during cardiac arrest resuscitation remains relatively crude, primarily comprising ECG monitoring and manual pulse checks. Various modalities have since been tested to estimate hemodynamic, cerebral hemodynamic, gas exchange, and metabolic conditions during resuscitation, all in an attempt to provide insight into the likelihood of return of spontaneous circulation (ROSC) and subsequent neurologic recovery. Point-of-care echocardiography has become prevalent as a decision tool for termination of resuscitation, in that the absence of cardiac motion is associated with the absence of ROSC.  A useful test to prognosticate clinical outcomes during cardiac arrest resuscitation is a very desirable clinical tool. Point-of-care echocardiography has become common in clinical practice without recognizing the potential pitfalls or potential for misinterpretation. | This topic was prioritized by the ALS Task Force based on the high prevalence of point-of-care echocardiography during cardiac arrest without recognizing the potential pitfalls for misinterpretation as an adjunct diagnostic and/or prognostic tool. Given the high penetration of point-of-care echocardiography during cardiac arrest into current clinical practice, a comprehensive and rigorous summary of its intra-arrest prognostic capabilities provides valuable information to both the resuscitation science community and bedside clinicians. |
| Desirable Effects How substantial are the desirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Trivial ○ Small ○ Moderate ○ Large ● **Varies** ○ Don't know | The primary desirable effect is to prognosticate clinical outcomes with both classification accuracy and certainty during cardiac arrest resuscitation. This could either result in continuing resuscitation efforts in patients that could still survive or terminating resuscitation in patients who would ultimately prove refractory to resuscitation efforts.   |  |  |  | | --- | --- | --- | |  | Outcome (+) (e.g. ROSC) | Outcome (-)  (e.g. No ROSC) | | Outcome (+)  (e.g. organized motion present) | True Positive | False Positive | | Outcome (-)  (e.g. organized motion absent) | False Negative | True Negative |   We found wide variability in both the point estimates and certainty around point estimates to prognosticate clinical outcomes.  Some sonographic findings had higher ranges of specificity (Sp) for clinical outcomes, but the certainty of this evidence is very low.  No sonographic finding had sufficient and/or consistent sensitivity (Sn) for any clinical outcome to be used a sole criterion to terminate resuscitative efforts, but the certainty of this evidence is very low.   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | US Findings | Outcome | | | | | | | ROSC | Survival Hospital Admission | Survival Hospital DC | Survival 180 days | Good Neuro Outcome Hospital DC | Good Neuro Outcome 180 days | | Organized motion (unspecified timing) | Sn range 0.34 to 0.79 | Sn range 0.39 to 1.00 | Sn range 0.67 to 1.00 | Sn 1.00 (95% CI 0.40-1.00) |  |  | | Sp range  0.68 to 0.96 | Sp range 0.91 to 0.91 | Sp range 0.51 to 0.89 | Sp 0.49 (95% CI 0.34-0.64) | | Unspecified motion (initial echo) | Sn range 0.25 to 0.64 | Sn range 0.11 to 0.92 | Sn range 0.06 to 0.91 |  | Sn 1.00 (95% CI 0.03-1.00) |  | | Sp range 0.78 to 1.00 | Sp range 0.55 to 0.85 | Sp range 0.49 to 0.94 | Sp 0.78 (95% CI 0.62-0.89) | | Unspecified motion (every echo) |  | Sn range 0.46 to 0.80 |  |  |  |  | | Sp range  0.92 to 1.00 | | Unspecified motion (unspecified timing) | Sn range 0.62 to 1.00 | Sn range 0.72 to 0.86 | Sn 0.48 (95% CI 0.28-0.69) |  | Sn 1.0 (95% CI 0.03-1.00) | Sn 1.0 (95% CI 0.40-1.00) | | Sp range 0.33 to 0.98 | Sp range 0.60 to 0.84 | Sp 0.77 (95% CI 0.69-0.83) | Sp 0.86 (95% CI 0.75-0.93) | Sp 0.49 (95% CI 0.34-0.64) | | Return of organized motion (subsequent echo) | Sn 0.67 (95% CI 0.22-0.96) |  | Sn 0.50 (95% CI 0.01-0.99) |  |  |  | | Sp 1.00 (95% CI 0.77-1.00) | Sp 0.79 (95% CI 0.54-0.94) | | Visibly clotted intra-cardiac blood (20-30 min CPR) | Sn 0.00 (95% CI 0.00-0.46) |  | Sn 0.00 (95% CI 0.00-0.84) |  |  |  | | Sp 0.21 (95% CI 0.05-0.51) | Sp 0.45 (95% CI 0.23-0.68) | | Sonographic evidence treatable pathology | Sn range 0.00 to 1.00 | Sn range 0.03 to 0.04 | Sn range 0.00 to 0.15 |  |  |  | | Sp range  0.84 to 0.94 | Sp range  0.95 to 0.99 | Sp range  0.89 to 0.98 | | When considering prognostic tests that influence the decision to continue or terminate resuscitation, it is helpful to consider the body of work on the Universal Termination of Resuscitation (TOR) guidelines. Universal TOR rules have approximately a 0.5% false positive rate (erroneously recommending termination in patients who would have otherwise survived). (Morrison 2006 478)  It is generally considered more acceptable to continue resuscitation efforts that prove futile than to erroneously terminate resuscitation in a patient who would have otherwise survived. |
| Undesirable Effects How substantial are the undesirable anticipated effects? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Large ○ Moderate ○ Small ○ Trivial ● **Varies** ○ Don't know | The primary undesirable effect is falsely interpreting sonographic findings or overestimating the prognostic strength of sonographic findings during the course of resuscitation. This could either result in continuing futile resuscitation efforts or prematurely terminating resuscitation in patients that could have otherwise survived. The additional time spent continuing otherwise futile resuscitation efforts is likely a small incremental burden of resource utilization. Whereas is it very undesirable to prematurely terminate resuscitation in patients that could have otherwise survived.  We found wide variability in both the point estimates and certainty around point estimates to prognosticate clinical outcomes.  See the associated Consensus on Science and Treatment Recommendation (CoSTR) document that delineates the assorted sensitivities, specificities, and odds ratios for each sonographic finding and clinical outcome. The prognostic implications of sonographic findings during cardiac arrest are at high risk of over-interpretation or providing false reassurance.  A secondary undesirable effect is additional interruptions in otherwise continuous chest compressions (Huis In’t Veld 2017 95, Clattenburg 2018 65). | When considering prognostic tests that influence the decision to continue or terminate resuscitation, it is helpful to consider the body of work on the Universal Termination of Resuscitation (TOR) guidelines. Universal TOR rules have approximately a 0.5% false positive rate (erroneously recommending termination in patients who would have otherwise survived). (Verbeek 2002 671)  It is generally considered more acceptable to continue resuscitation efforts that prove futile than to erroneously terminate resuscitation in a patient who would have otherwise survived. |
| Certainty of evidence What is the overall certainty of the evidence of effects? | | |
| Judgement | Research evidence | Additional considerations |
| ● **Very low** ○ Low ○ Moderate ○ High ○ No included studies | The certainty of evidence of the prognostic ability of point-of-care echocardiography during cardiac arrest was uniformly very low due to risk of bias, inconsistency, and imprecision.   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | US Findings | Outcome | | | | | | | ROSC | Survival Hospital Admission | Survival Hospital DC | Survival 180 days | Good Neuro Outcome Hospital DC | Good Neuro Outcome 180 days | | Organized motion (unspecified timing) | VERY LOW | VERY LOW | VERY LOW | VERY LOW |  |  | | Unspecified motion (initial echo) | VERY LOW | VERY LOW | VERY LOW |  | VERY LOW |  | | Unspecified motion (every echo) |  | VERY LOW |  |  |  |  | | Unspecified motion (unspecified timing) | VERY LOW | VERY LOW | VERY LOW |  | VERY LOW | VERY LOW | | Return of organized motion (subsequent echo) | VERY LOW |  | VERY LOW |  |  |  | | Visibly clotted intra-cardiac blood (20-30 min CPR) | VERY LOW |  | VERY LOW |  |  |  | | Sonographic evidence treatable pathology | VERY LOW | VERY LOW | VERY LOW |  |  |  | |  |
| Values Is there important uncertainty about or variability in how much people value the main outcomes? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Important uncertainty or variability ● **Possibly important uncertainty or variability** ○ Probably no important uncertainty or variability ○ No important uncertainty or variability | None of the identified studies specifically address this question. | The COSCA (Core Outcome Set for Cardiac Arrest) project demonstrates that patients value longer term outcomes (Haywood 2018 147). The included studies did contain the clinical outcomes survival to 180 days and good neurologic outcome at 180 days. Health related quality of life outcomes were not addressed in the included studies. |
| Balance of effects Does the balance between desirable and undesirable effects favor the intervention or the comparison? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● **Don't know** | No sonographic finding had sufficiently or consistently high sensitivity to support its use as a sole criterion to terminate resuscitation. Some sonographic findings tended to have higher ranges of specificity than others for clinical outcomes. See Table above under “Desirable effects”. In this manner, point-of-care echocardiography might be useful to identify sonographic findings that support continuation of resuscitation. However, the presence or absence of any particular finding had insufficient sensitivity to use a sole criterion for termination of resuscitation. Thus, paradoxically, the presence of certain sonographic findings might encourage the continuation of resuscitative efforts, but absence of the same is not sufficient justification (in isolation) to cease resuscitative efforts.  Furthermore, the lack of standardized uniform definitions of cardiac motion in the included studies, the wide variability in both point estimates and confidence intervals around point estimates, and the very low certainty of evidence render these data extremely difficult to interpret. |  |
| Resources required How large are the resource requirements (costs)? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Large costs ○ Moderate costs ○ Negligible costs and savings ○ Moderate savings ○ Large savings ○ Varies ● **Don't know** | None of the identified studies specifically address this question. | Point-of-care echocardiography is available in most Emergency Departments. We expect additional fixed and/or recurring equipment costs to be low. Introducing point-of-care echocardiography to new inpatient or prehospital settings carries new fixed and recurring equipment costs.  We expect the incremental cost of continuing resuscitation efforts in the same setting in which they have already been started is low. The cost to continue resuscitation efforts in a new setting (e.g. transitioning from prehospital to Emergency Department setting) is higher. |
| Certainty of evidence of required resources What is the certainty of the evidence of resource requirements (costs)? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Very low ○ Low ○ Moderate ○ High ● **No included studies** | None of the identified studies specifically address this question. | Unknown |
| Cost effectiveness Does the cost-effectiveness of the intervention favor the intervention or the comparison? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Favors the comparison ○ Probably favors the comparison ○ Does not favor either the intervention or the comparison ○ Probably favors the intervention ○ Favors the intervention ○ Varies ● **No included studies** | None of the identified studies specifically address this question. | Considerations of cost are noted above under “Resources required”.  The effectiveness of prognostication with point-of-care echocardiography during cardiac arrest is currently uncertain. |
| Equity What would be the impact on health equity? | | |
| Judgement | Research evidence | Additional considerations |
| ○ Reduced ○ Probably reduced ○ Probably no impact ○ Probably increased ○ Increased ○ Varies ● **Don't know** | None of the identified studies specifically address this question. | Due to fixed and recurring equipment costs, there may be global or regional discrepancies in the availability of point-of-care echocardiography during cardiac arrest. |
| Acceptability Is the intervention acceptable to key stakeholders? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ● **Don't know** | None of the identified studies specifically address this question. | Point-of-care echocardiography is already commonly used in the Emergency Department to guide treatment decisions during cardiac arrest. It is difficult to estimate the prevalence of use among cases of cardiac arrest treated in the Emergency Department, but the existence of multiple professional society statements and proposed sonographic protocols support its wide acceptance.  Introducing point-of-care echocardiography to new inpatient or prehospital settings may generate new challenges to acceptability in those clinical settings. |
| Feasibility Is the intervention feasible to implement? | | |
| Judgement | Research evidence | Additional considerations |
| ○ No ○ Probably no ○ Probably yes ○ Yes ○ Varies ● **Don't know** | None of the identified studies specifically address this question.  A central component to operational feasibility of prognostication with point-of-care echocardiography is sufficient inter-rater reliability. Only two included studies (Flato 2015 1; Gaspari 2016 33) reported estimates of inter-rater reliability (Kappa 0.63 and 0.93, respectively). Other estimates report moderate inter-rater reliability (Krippendorff’s α0.47) (Hu 2018 193) | Point-of-care echocardiography is already commonly used in the Emergency Department to guide treatment decisions during cardiac arrest. It is difficult to estimate the prevalence of use among cases of cardiac arrest treated in the Emergency Department, but the existence of multiple professional society statements and proposed sonographic protocols support its wide acceptance.  Introducing point-of-care echocardiography to new inpatient or prehospital settings may generate new challenges to feasibility in those clinical settings. |

# Summary of judgements

|  | **Judgement** | | | | | | |
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| **Problem** | No | Probably no | Probably yes | **Yes** |  | Varies | Don't know |
| **Desirable Effects** | **Trivial** | **Small** | Moderate | Large |  | **Varies** | **Don't know** |
| **Undesirable Effects** | Large | **Moderate** | Small | Trivial |  | **Varies** | **Don't know** |
| **Certainty of evidence** | **Very low** | Low | Moderate | High |  |  | No included studies |
| **Values** | Important uncertainty or variability | **Possibly important uncertainty or variability** | **Probably no important uncertainty or variability** | No important uncertainty or variability |  |  |  |
| **Balance of effects** | Favors the comparison | **Probably favors the comparison** | Does not favor either the intervention or the comparison | **Probably favors the intervention** | Favors the intervention | Varies | **Don't know** |
| **Resources required** | Large costs | Moderate costs | Negligible costs and savings | Moderate savings | Large savings | Varies | **Don't know** |
| **Certainty of evidence of required resources** | Very low | Low | Moderate | High |  |  | **No included studies** |
| **Cost effectiveness** | Favors the comparison | Probably favors the comparison | Does not favor either the intervention or the comparison | Probably favors the intervention | Favors the intervention | Varies | **No included studies** |
| **Equity** | Reduced | Probably reduced | Probably no impact | Probably increased | Increased | Varies | **Don't know** |
| **Acceptability** | No | Probably no | **Probably yes** | Yes |  | Varies | **Don't know** |
| **Feasibility** | No | Probably no | **Probably yes** | Yes |  | Varies | **Don't know** |

# Type of recommendation

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| **Strong recommendation against the intervention** | **Conditional recommendation against the intervention** | **Conditional recommendation for either the intervention or the comparison** | **Conditional recommendation for the intervention** | **Strong recommendation for the intervention** |
| ○ | ● | ○ | ○ | ○ |

# Conclusions

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| Recommendation |
| We suggest against using point-of-care echocardiography for prognostication during in-hospital or out-of-hospital cardiac arrest (weak recommendation, very low certainty of evidence). |
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| Justification |
| This topic was prioritized by the ALS Task Force based on the high prevalence of point-of-care echocardiography during cardiac arrest without recognizing the potential pitfalls for misinterpretation as an adjunct prognostic tool. Given the high penetration of point-of-care echocardiography during cardiac arrest into current clinical practice, a comprehensive and rigorous summary of its intra-arrest prognostic capabilities provides valuable information to both the resuscitation science community and bedside clinicians.  In making these recommendations, the ALS Task Force considered the following:   * There were inconsistent definitions and terminology around sonographic evidence of cardiac motion. This included wide variation in the classification of anatomy, type of motion, and timing of point-of-care echocardiogram. We strongly encourage the establishment of uniform definitions and terminology to describe sonographic findings of cardiac activity during cardiac arrest. * Most of the identified studies suffer from high risk of bias related to prognostic factor measurement, outcome measurement, lack of adjustment for other prognostic factors, and confounding from self-fulfilling prophecy and unspecified timing of point-of-care echocardiography. Due to the risk of bias and heterogeneity between studies, no meta-analyses were performed. The evidence supporting use of point-of-care echocardiography as a prognostic tool during cardiac arrest is uniformly of very low certainty. Clinicians should interpret sonographic findings during cardiac arrest in light of these limitations. We strongly encourage subsequent investigations of point-of-care echocardiography during cardiac arrest to employ methodology that mitigates these risks of bias. * Only included 2 studies (Flato 2015 1; Gaspari 2016 33) reported estimates of inter-rater reliability (Kappa 0.63 and 0.93). One additional study estimated moderate inter-rater reliability (Krippendorff’s α 0.47) (Hu 2018 193). We strongly encourage subsequent investigations of point-of-care echocardiography during cardiac arrest to estimate inter-rater reliability. * No sonographic finding had sufficient and/or consistent sensitivity for any clinical outcome to be used a sole criterion to terminate resuscitative efforts, but the certainty of this evidence is very low. * Some sonographic findings had higher ranges of specificity for clinical outcomes, but the certainty of this evidence is very low. * The impact of extracorporeal CPR (ECPR) on the prognostic accuracy of point-of-care echocardiography is uncertain. * Point-of-care echocardiography may still have utility to diagnose treatable etiologies of cardiac arrest or to intermittently assess hemodynamic responses to resuscitative treatments. These applications are not within the scope of this particular PICOST question. We do caution against over-interpreting the finding of right ventricular dilation in isolation as a diagnostic indicator of massive pulmonary embolism. Right ventricular dilation begins a few minutes after onset of cardiac arrest as blood shifts from the systemic circulation to the right heart along its pressure gradient. (Querellou 2009 769, Blanco 2016 15) Right ventricular dilation was uniformly observed in a porcine model of cardiac arrest across etiologies of hypovolemia, hyperkalemia, and primary arrhythmia. (Aagaard 2017 e963) * Clinicians should be cautious about introducing additional interruptions in chest compressions with a transthoracic approach to point-of-care echocardiography during cardiac arrest. (Huis In’t Veld 2017 95, Clattenburg 2018 65). * Point-of-care echocardiography is subject to availability of equipment and skilled operators. |

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| Subgroup considerations |
| We identified the following *a priori* subgroups: witnessed vs. unwitnessed collapse, shockable vs. non-shockable initial cardiac rhythm, and in-hospital vs. out-of-hospital cardiac arrest. However, risk of bias and other confounding precluded the ability to pool data or conduct meaningful analyses of these subgroups. |

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| Implementation considerations |
| Until such time as uniform definitions and terminology to describe sonographic findings of cardiac activity during cardiac arrest are established, subsequent investigations employ methodology that mitigates the inherent risks of bias and confounding, and subsequent investigations characterize inter-rater reliability, we suggest against using point-of-care echocardiography for prognostication during in-hospital or out-of-hospital cardiac arrest.  Otherwise, point-of-care echocardiography is already commonly used in the Emergency Department to guide treatment decisions during cardiac arrest. It is difficult to estimate the prevalence of use among cases of cardiac arrest treated in the Emergency Department, but the existence of multiple professional society statements and proposed sonographic protocols support its wide acceptance.  Introducing point-of-care echocardiography to new inpatient or prehospital settings may generate new implementation challenges. |

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| Monitoring and evaluation |
| Until such time as uniform definitions and terminology to describe sonographic findings of cardiac activity during cardiac arrest are established, subsequent investigations employ methodology that mitigates the inherent risks of bias and confounding, and subsequent investigations characterize inter-rater reliability, we suggest against using point-of-care echocardiography for prognostication during in-hospital or out-of-hospital cardiac arrest.  Otherwise, we encourage the use of robust quality assurance programs with expert oversight to ensure both valid and reliable interpretation of sonographic findings. |

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| Research priorities |

There is no standardized or uniform definition of cardiac motion visualized on point-of-care echocardiography during cardiac arrest.

There are very few prognostic factor studies of point-of-care echocardiography during cardiac arrest performed with methodology that minimizes risk of bias.

The inter-rater reliability of point-of-care echocardiography during cardiac arrest is uncertain.

There were no studies identified that provided data on resource requirement, cost-effectiveness, equity, acceptability, or feasibility.