ELECTRONIC SUPPLEMENTARY MATERIAL

Klowak JA *et al.*: Diagnostic test accuracy for cessation of circulation during death determination: a systematic review

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eAppendix 1 Search strategy for MEDLINE

Database: Ovid MEDLINE(R) ALL 1946 to April 26, 2021
Date search conducted: April 27, 2021
Strategy:

1 exp *Heart Arrest/ (36249)
2 ((arrest$1 or dead or death$1 or flat-lin* or flatlin*) adj2 (cardi* or circulat* or heart)).tw,kf. (95494)
3 asystol*.tw,kf. (4407)
4 (cessation adj5 (cardiac rhythm$1 or circulat* or heart function*)).tw,kf. (237)
5 ((cessation or terminat*) adj3 cardi* resuscitation).tw,kf. (43)
6 or/1-5 [Set 1: cardiac arrest or circulatory death] (107656)
7 Monitoring, Physiologic/ (56086)
8 "Sensitivity and Specificity"/ (353899)
9 Vital Signs/ (1516)
10 detect*.tw,kf. (2454927)
11 measurement*.ti. (188631)
12 measurement*.ab. /freq=2 (262819)
13 monitor*.tw,kf. (852063)
14 vital sign$1.tw,kf. (15764)
15 or/7-14 [Set 2: vital signs monitoring] (3653026)
16 Arterial Pressure/ (6045)
17 Blood Pressure/ph [Physiology] (53044)
18 Blood Pressure Determination/ (28681)
19 ABP*.tw,kf. (10939)
20 ((arter* or aortic) adj3 (pressure$1 or tension$1)).tw,kf. (123551)
21 arterial line$1.tw,kf. (1451)
22 or/16-21 [Set 3: arterial line] (197650)
23 exp Auscultation/ (9235)
24 *Echocardiography/ (29695)
25 exp Echocardiography, Doppler/ (28957)
26 *Electrocardiography/ (67040)
27 Oximetry/ (13386)
28 Palpation/ (7710)
29 Perfusion Index/ (30)
30 Pulse/ (17022)
31 (absen* adj2 (breath sound$1 or breathing or heart sound$1 or pulse)).tw,kf. (366)
32 auscultat*.tw,kf. (6697)
33 (echo-cardiogra* or echocardiogra*).ti. (46775)
34 (echo-cardiogra* or echocardiogra*).ab. /freq=2 (53417)
35 (ECG* or EKG* or electro-cardiogra* or electrocardiogra*).ti. (44596)
36 (ECG* or EKG* or electro-cardiogra* or electrocardiogra*).ab. /freq=2 (47641)
37 (oximet* adj3 pulse).tw,kf. (9142)
38 (palpa* adj3 pulse).tw,kf. (572)
39 palpat*.tw,kf. (15554)
40 (perfusion adj2 (measur* or index)).tw,kf. (4831)

41 or/23-40 [Set 4: alternate means of measuring circulation] (269889)
42 and/6,15,22 [Sets 1 and 2 and 3] (739)
43 and/6,15,41 [Sets 1 and 2 and 4] (2710)
44 42 or 43 (3326)
45 (exp animals/ or exp animal experimentation/ or exp models animal/ or exp vertebrates/) not (exp humans/ or exp human experimentation/) (4819180)
46 ((ape or apes or animal* or baboon* or beagle* or cat or cats or chicken or chickens or chimp* or dog or dogs or feline* or fish or hamster or hamsters or horse or horses or lapin* or macaque* or mouse or mice or nonhuman* or non human* or pig or piglet* or pigs or porcine or rabbit or rabbit or raccoon or raccoons or racehorse or racehorses or rat or rats or rodent* or swine* or sheep or zebrafish*) not (adults or children or human or humans or infants or patient or patients or people or seniors)).ti,kf. (2178262)
47 45 or 46 (5186992)
48 44 not 47 [exclude animal studies] (2980)
49 remove duplicates from 48 [MEDLINE results for export] (2977)

eAppendix 2 Search strategy for Embase

Database: Ovid Embase Classic+Embase 1947 to April 26
Date search conducted: April 27, 2021
Strategy:

1 exp *heart arrest/ (40552)
2 ((arrest$1 or dead or death$1 or flat-lin* or flatlin*) adj2 (cardi* or circulat* or heart)).tw,kw. (159504)
3 asystol*.tw,kw. (7840)
4 (cessation adj5 (cardiac rhythm$1 or circulat* or heart function*)).tw,kw. (375)
5 ((cessation or terminat*) adj3 cardi* resuscitation).tw,kw. (64)
6 or/1-5 [Set 1: cardiac arrest or circulatory death] (170024)
7 physiologic monitoring/ (5787)
8 "sensitivity and specificity"/ (393851)
9 vital sign/ (26094)
10 detect*.tw,kw. (3258606)
11 monitor*.tw,kw. (1204958)
12 vital sign$1.tw,kw. (31899)
13 or/7-12 [Set 2: vital signs monitoring] (4472611)
14 exp *arterial pressure/ (13354)
15 blood pressure monitoring/ (50751)
16 ABP*.tw,kw. (18788)
17 ((arter* or aortic) adj3 (pressure$1 or tension$1)).tw,kw. (183809)
18 arterial line$1.tw,kw. (2796)
19 or/14-18 [Set 3: arterial line] (244869)
20 exp auscultation/ (19395)
21 exp Doppler echocardiography/ (29685)
22 *echocardiography/ (43444)
23 *electrocardiography/ (50717)
24 palpation/ (21787)
25 perfusion index/ (265)
26 pulse oximetry/ (16729)
27 *pulse rate/ (6322)
28 (absen* adj2 (breath sound$1 or breathing or heart sound$1 or pulse)).tw,kw. (815)
29 auscultat*.tw,kw. (11523)
30 (echo-cardiogra* or echocardiogra*).ti. (69029)
31 (echo-cardiogra* or echocardiogra*).ab. /freq=2 (97131)
32 (ECG* or EKG* or electro-cardiogra* or electrocardiogra*).ti. (57837)
33 (ECG* or EKG* or electro-cardiogra* or electrocardiogra*).ab. /freq=2 (84302)
34 (oximet* adj3 pulse).tw,kw. (13752)
35 (palpa* adj3 pulse).tw,kw. (1051)
36 palpat*.tw,kw. (26892)
37 (perfusion adj2 (measur* or index)).tw,kw. (7017)
38 or/20-37 [Set 4: alternate means of measuring circulation] (378053)
39 and/6,13,19 [Sets 1 and 2 and 3] (1321)
40 and/6,13,38 [Sets 1 and 2 and 4] (4426)

41 39 or 40 (5522)
42 (exp animals/ or exp animal experiment/ or exp animal experimentation/ or exp models animal/ or nonhuman/ or exp vertebrate/ or exp vertebrates/) not (exp humans/ or exp human experiment/ or exp human experimentation/) (7555078)
43 ((ape or apes or animal* or baboon* or beagle* or cat or cats or chicken or chickens or chimp* or dog or dogs or feline* or fish or hamster or hamsters or horse or horses or lapin* or macaque* or mouse or mice or nonhuman* or non human* or pig or piglet* or pigs or porcine or rabbit or rabbit or raccoon or raccoons or racehorse or racehorses or rat or rats or rodent* or swine* or sheep or zebrafish*) not (adults or children or human or humans or infants or patient or patients or people or seniors)).ti. (2590176)
44 42 or 43 (7833758)
45 41 not 44 [exclude animal studies] (4993)
46 (Conference Abstract or Conference Paper or Conference Review).pt. (4874389)
47 45 and 46 (2242)
48 limit 47 to yr="2018-2021" (689)
49 45 not 46 [exclude conference proceedings] (2751)
50 48 or 49 [add proceedings from last 3 yrs] (3440)
51 remove duplicates from 50 [Embase results for export] (3357)

eAppendix 3 Search strategy for Cochrane Central Register of Controlled Trials

Database: EBM Reviews - Cochrane Central Register of Controlled Trials March 2021
Date search conducted: April 27, 2021
Strategy:

1 exp Heart Arrest/ (1998)
2 ((arrest$1 or dead or death$1 or flat-lin* or flatlin*) adj2 (cardi* or circulat* or heart)).tw. (14791)
3 asystol*.tw. (312)
4 (cessation adj5 (cardiac rhythm$1 or circulat* or heart function*)).tw. (16)
5 ((cessation or terminat*) adj3 cardi* resuscitation).tw. (0)
6 or/1-5 [Set 1: cardiac arrest or circulatory death] (15477)
7 Monitoring, Physiologic/ (2256)
8 "Sensitivity and Specificity"/ (9350)
9 Vital Signs/ (98)
10 detect*.tw. (93291)
11 measurement*.tw. (130467)
12 monitor*.tw. (91508)
13 vital sign$1.tw. (15003)
14 or/7-13 [Set 2: vital signs monitoring] (299199)
15 Arterial Pressure/ (443)
16 Blood Pressure/ph [Physiology] (0)
17 Blood Pressure Determination/ (1123)
18 ABP*.tw. (2112)
19 ((arter* or aortic) adj3 (pressure$1 or tension$1)).tw. (20487)
20 arterial line$1.tw. (495)
21 or/15-20 [Set 3: arterial line] (23778)
22 exp Auscultation/ (174)
23 Echocardiography/ (2771)
24 exp Echocardiography, Doppler/ (1127)
25 Electrocardiography/ (7746)
26 Oximetry/ (824)
27 Palpation/ (354)
28 Perfusion Index/ (1)
29 Pulse/ (1425)
30 (absen* adj2 (breath sound$1 or breathing or heart sound$1 or pulse)).tw. (72)
31 auscultat*.tw. (858)
32 (echo-cardiogra* or echocardiogra*).ti. (2253)
33 (echo-cardiogra* or echocardiogra*).ab. /freq=2 (4442)
34 (ECG* or EKG* or electro-cardiogra* or electrocardiogra*).ti. (1957)
35 (ECG* or EKG* or electro-cardiogra* or electrocardiogra*).ab. /freq=2 (8134)
36 (oximet* adj3 pulse).tw. (3449)
37 (palpa* adj3 pulse).tw. (112)
38 palpat*.tw. (2343)
39 (perfusion adj2 (measur* or index)).tw. (789)
40 or/22-39 [Set 4: alternate means of measuring circulation] (30672)

41 and/6,14,21 [Sets 1 and 2 and 3] (152)
42 and/6,14,40 [Sets 1 and 2 and 4] (436)
43 41 or 42 (550)
44 remove duplicates from 43 [CENTRAL results for export] (545)

eAppendix 4 Search strategy for Web of Science Core Collection

Database: Web of Science Core Collection: Science Citation Index Expanded (SCI-EXPANDED) --1900-present
Date search conducted: April 27, 2021
Strategy:
1 TS=(((arrest* or dead or death* or "flat lin*" or flatlin*) NEAR/2 (cardi* or circulat* or heart)) or asystol* or (cessation NEAR/5 ("cardiac rhythm*" or circulat* or "heart function*")) or ((cessation or terminat*) NEAR/3 "cardi* resuscitation"))
Indexes=SCI-EXPANDED Timespan=All years
2 TS=(detect* or monitor* or "vital sign*") or TI=measurement*
Indexes=SCI-EXPANDED Timespan=All years
3 TS=(((arter* or aortic) NEAR/3 (pressur* or tension*)) or "arterial line*")
Indexes=SCI-EXPANDED Timespan=All years
4 TS=((absen* NEAR/2 ("breath sound*" or breathing or "heart sound*" or pulse)) or auscultat* or (oximet* NEAR/3 pulse) or (palpa* NEAR/3 pulse) or palpat* or (perfusion NEAR/2 (measur* or index))) or TI=("echo cardiogra*" or echocardiogra* or ECG* or EKG* or "electro cardiogra*" or electrocard ogra*) *Indexes=SCI-EXPANDED Timespan=All years*
5 #3 AND #2 AND #1
Indexes=SCI-EXPANDED Timespan=All years
6 #4 AND #2 AND #1
Indexes=SCI-EXPANDED Timespan=All years
7 #6 OR #5
Indexes=SCI-EXPANDED Timespan=All years
8 TI=((ape or apes or animal* or baboon* or beagle* or cat or cats or chicken or chickens or chimp* or dog or dogs or feline* or fish or hamster or hamsters or horse or horses or lapin* or mouse or mice or nonhuman* or "non human*" or pig or piglet* or pigs or porcine or rabbit or rabbit or raccoon or raccoons or racehorse or racehorses or rat or rats or rodent* or swine* or sheep) not (adults or children or human or humans or infants or patient or patients or people or seniors))
Indexes=SCI-EXPANDED Timespan=All years
9 #7 NOT #8
Indexes=SCI-EXPANDED Timespan=All years

eAppendix 5 PRISMA 2020 Main Checklist

Topic	No.	Item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Page 1, Title
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Page 4, Introduction Paragraph 2
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Page 4, Introduction Paragraph 2
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Page 4-5, Methods, Eligibility criteria
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Page 5, Methods, Information sources
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Appendices 1-4
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Page 5, Methods, Selection process

Topic	No.	Item	Location where item is reported
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Page 5, Methods, Data collection and items
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Page 5, Methods, Data collection and items
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Page 5, Methods, Data collection and items
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Page 5, Methods, Risk of bias assessment
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Page 5, Methods, Data collection and items
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item 5)).	Page 5, Methods, Synthesis methods

Topic	No.	Item	Location where item is reported
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Page 5, Methods, Synthesis methods
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Page 5, Methods, Synthesis methods
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Page 5, Methods, Synthesis methods
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Page 5, Methods, Synthesis methods
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Page 6, Methods, Certainty assessment and reporting bias assessment
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Page 6, Methods, Certainty assessment and reporting bias assessment
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Page 6, Results, Study selection and characteristics

Topic	No.	Item	Location where item is reported
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	NA
Study characteristics	17	Cite each included study and present its characteristics.	Table 1
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Table 2
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Table 3a, 3b
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Table 3a, 3b
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	NA
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	NA
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Table 3a, 3b
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Table 3a, 3b

Topic	No.	Item	Location where item is reported
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Page 9, Discussion, Paragraph 1
	23b	Discuss any limitations of the evidence included in the review.	Page 10, Discussion, Paragraph 7
	23c	Discuss any limitations of the review processes used.	Page 10, Discussion, Paragraph 7
	23d	Discuss implications of the results for practice, policy, and future research.	Page 10, Discussion, Paragraph 7
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Page 4, Methods, Paragraph 1
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Page 4, Methods, Paragraph 1
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Page 4, Methods, Risk of bias assessment
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Page 1, Funding
Competing interests	26	Declare any competing interests of review authors.	Page 1, Competing interests

Topic	No.	Item	Location where item is reported
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Page 4-5, Methods

eAppendix 6 PRISMA 2020 Abstract Checklist

Topic	No.	Item	Reported?
TITLE			
Title	1	Identify the report as a systematic review.	Yes
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	Yes
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	Yes
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	Yes
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	Yes
Synthesis of results	6	Specify the methods used to present and synthesize results.	Yes
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	Yes
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	Yes
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	Yes
Interpretation	10	Provide a general interpretation of the results and important implications.	Yes

Topic	No.	Item	Reported?
OTHER			
Funding	11	Specify the primary source of funding for the review.	Yes
Registration	12	Provide the register name and registration number.	Yes

eAppendix 7 Bibliography

1. Blaivas M. Discordance Between Pulse Detection and Emergent Echocardiography Findings in Adult Cardiopulmonary Arrest Patients. Annals of Emergency Medicine. 2008;52(4):S128-S.
2. Caccioppola A, Carbonara M, Macrì M, Longhi L, Magnoni S, Ortolano F, et al. Ultrasound-tagged near-infrared spectroscopy does not disclose absent cerebral circulation in brain-dead adults. Br J Anaesth. 2018;121(3):588-94.
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eAppendix 8 Data abstraction of Blaivas 2008

Domain	
Methods	Country: USA Study aim: To define the frequency of focused bedside echocardiography (Echo) during cardiopulmonary resuscitation (CPR) corresponds to pulse checks in patients undergoing CPR. Design: Prospective observational Blinded: No
Population	Study population: Patient in cardiopulmonary arrest in ER Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 226 Age, mean/median (SD/Range): NR
Reference test	Test type: Palpable pulse Test details: Nurses and physicians attempted to locate pulses while one emergency physician performed a brief Echo of the heart with a compact ultrasound machine. Definition of +/- circulation: NR
Comparator test(s) description	Comparator test 1: Cardiac Echo Test details: Brief Echo of the heart with a compact US machine. Echo checks were limited to the time available during pulse checks and ended when the treating emergency physician ordered resumption of chest compressions. Definition of +/- circulation: NR Comparator test 2: Doppler US on carotid artery Test details: If Echo suggested sufficient EF to generate blood flow but pulse check was negative, the carotid arteries were evaluated with Doppler when interference with resuscitative efforts could be avoided. Definition of +/- circulation: NR
Outcomes for comparator test(s)	**Cardiac Echo** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: 11% Definition of false negative: NR Definition of false positive: When Echo shows myocardial standstill or negligible EF, but pulse detected by palpation. Additional details: Total of 248 Echo checks revealed EF of severely depressed or better and were felt to likely generate a detectable blood pressure. In 47% of these Echo checks, no pulses were palpable. In 11% of cases when electrical cardiac activity was noted on the monitor and a health care provider noted palpable pulses, the echo showed either myocardial standstill or negligible EF

	Doppler US on carotid Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: 37% Reported false positive: NR Definition of false negative: If palpable pulse is seen as index test, then false negative would be when Doppler shows flow, but palpable pulse shows no flow. Definition of false positive: NR Additional details: In 37% of cases when Echo showed severely depressed or better EF but no pulses were palpable. In these cases, all patients showed flow in the carotid on both color and pulse wave Doppler.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	No comparison to arterial line, so it was difficult to decide which is one was the index test. If palpable pulse is the index test, then FP (saying circulation ceased when it hasn't) is when palpable pulse is absent and comparator test says circulation is present; but we know palpable pulse is unreliable to detect arrest of circulation.

eAppendix 9 Data abstraction of Caccioppola *et al.* 2018

Domain	
Methods	Country: Italy Study aim: To examine whether UT-NIRS properly detects the absence of cerebral blood flow (CBF) in brain-dead patients in comparison to healthy volunteers. Design: Case-control Blinded: No
Population	Study population: Healthy volunteers and brain-dead patients Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 20 healthy volunteers and 20 brain dead patients Age, mean/median (SD/Range): Healthy volunteers: Median age 26 (25-34) years Brain dead: Median 60 (54-76) years
Reference test	Test type: Clinical exam for brain death and TCCD and/or Angio-CT and/or angiography Test details: NR Definition of +/- circulation: Irreversible cessation of all brain function as clinically diagnosed and regulated by law in Italy.
Comparator test(s) description	Comparator test 1: UT-NIRS Test details: CerOx™ device (Ornim Medical, Kfar Saba, Israel) up until December 2015, when a new model (c-FLOW™; OrnimMedical) became available. In February 2016, the c-FLOW software was upgraded to a later version. Non-invasive and continuous check of deep tissue blood flow used to measure relative changes in blood flow that monitors regional microcirculatory blood flow in tissues. The device, connected to two probes, displays cerebral flow index (CFI) as a 'pure' number that ranges from 0 to 100.The normal CFI range is not known, and the manufacturer suggests considering relative changes in blood flow rather than absolute numbers. Definition of +/- circulation: NR
Outcomes for comparator test(s)	**NIRS rSO_2** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: Reported that NIRS indicated an apparently perfused brain in all pts Definition of false negative: Not stated by authors, but FN would be when NIRS shows there is flow in brain dead patients. Definition of false positive: NR Additional details: Indirect evidence from a population that is not population of interest for this SR. Healthy volunteers had median CFI of 33 (27-36). Brain dead patients had positive CFI, with a median of 41 (36-47) (significantly higher than healthy volunteers), with no significant differences between the two probes in

	patients with intact skull (Wilcoxon test; P=0.85). All recordings had an adequate signal quality. No significant differences were detected between measurements taken with the CerOx or the c-FLOW device. In 11 brain dead patients with no-flow confirmed on imaging, flow was detected by CFI in all of them.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	Populations are healthy controls and brain-dead patients and therefore were not our population of interest. However, findings have relevance.

eAppendix 10 Data abstraction of de Vries *et al.* 1997

Domain	
Methods	Country: Netherlands Study aim: To study the physiological effects of induced ventricular defibrillation and subsequent circulatory arrest for defibrillation threshold testing on the brain using the EEG, jugular bulb oximetry and near-infrared spectroscopy. Design: Prospective observational Blinded: No
Population	Study population: Patients undergoing implantation or revision of an automatic implantable cardioverter-defibrillator (AICD). Includes pediatrics: Yes Includes MAiD: No Includes DCD: No N (patients): 13 (59 episodes of circulatory arrest in these patients were studied). Age, mean/median (SD/Range): Calculated mean 49.8 years, reported range of 14-73 years old.
Reference test	Test type: Induced VF Test details: IAP in place but not defined based on IAP Definition of +/- circulation: VF = no circulation
Comparator test(s) description	Comparator test 1: NIRS rSO_2 Test details: The disposable sensor containing a light emitter and 2 receivers, was placed on the right side of the forehead, and secured with adhesive tape. Continuous monitoring. rSO_2 measurement, or NIRS, is based on the back-scatter of transcranially transmitted 2-wavelength incoherent light. NIRS based on pulse, or phase modulated laser is known to be superior to techniques based on the use of incoherent light but is also more complex. NIRS measures the oxygen saturation of a mixture of mainly venous and to a lesser extent capillary and arterial blood in a small sample of cortical tissue. Definition of +/- circulation: NR
Outcomes for comparator test(s)	**NIRS** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: In all 59 episodes of circulatory arrest that were studied rSO_2 fell instantly and EEG became isoelectric within 12+/- 4 seconds after induction. On successful defibrillation the rSO_2 increased to values in excess of pre-arrest levels and restored towards baseline. After induction of VF, the BP dropped to negligible values and the rSO_2 decreased.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant	Population is not the population of interest and study is on cerebral circulation using EEG

results	as "gold standard" reference test but results have relevance since setting is one of arrest of circulation. Authors concluded that measurement of rSO_2 by NIRS is an effective non-invasive tool for monitoring cerebral oxygenation during DFT-testing. However, specific values that would indicate cessation of circulation not reported.

eAppendix 11 Data abstraction of Dhanani *et al*. 2014

Domain	
Methods	Country: Canada Study aim: To assess the feasibility of conducting a prospective, observational study of continuous monitoring of vital signs for 30 minutes after the clinical determination of death in five Canadian ICUs. Design: Prospective observational Blinded: No
Population	Study population: ICU WLST Includes pediatrics: Yes Includes MAiD: No Includes DCD: No N (patients): 30 Age, mean/median (SD/Range): Pediatric site, in months (n = 4): 13.5 (range 1 to 25) Adult sites, in years (n = 37): 64 (range 30 to 90)
Reference test	Test type: Invasive arterial line Test details: No details on placement. Point of cessation of circulation determined by a minimum of 3 adjudicators. Definition of +/- circulation: Cessation of waveform activity
Comparator test(s) description	Comparator test 1: ECG Test details: Continuous 3-lead electrocardiogram Definition of +/- circulation: Determined by review by 3 adjudicators, isoelectric. Comparator test 2: EEG Test details: EEG monitoring was in place as standard of care in four patients (ALL ADULTS) at one study site. EEGs were recorded with a four-channel bipolar electroencephalogram monitor using four skin surface electrodes and a sub hairline montage. EEG waveform recordings were included for these subjects from withdrawal of life-sustaining therapies until 30 minutes after clinical declaration of death. Three adjudicators determined the time of isoelectric electroencephalogram and recorded any instances of resumption. Definition of +/- circulation: Isoelectric EEG is a surrogate for cessation of circulation. Isoelectric electroencephalogram was defined as no activity greater than 2 microvolts.
Outcomes for comparator test(s)	**ECG** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: Findings are that 3/30 pts had ECG and art BP stop as same time. In 22 subjects, ECG activity persisted continuously for a median of 08:16 (mm:ss; range,

	00:05–38:00) after absence of arterial blood pressure activity. In the other five subjects, electrocardiogram activity started and stopped intermittently for a median of 11:11 (mm:ss range, 00:37–36:29) after the absence of arterial blood pressure activity. Three subjects (10%, 3/30) (two of whom were children) had electrocardiogram activity that continued up to the end of the monitoring period. Considering these findings, ECG has no false positives but high false negative rate for arrest of circulation for death determination. The four children in this study had an isoelectric ECG that followed the last pulse by 0s (simultaneous), 11 min 11 s, 27 min 42 s and 36 min 29 s **EEG** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: In three subjects, isoelectric electroencephalogram preceded the cessation of electrocardiogram and arterial blood pressure by 04:00, 10:00, 10:10 (mm:ss), respectively. In the remaining subject, delta and theta waveform activity persisted for 26:08 (mm:ss) after cessation of arterial blood pressure activity. Once ceased, no resumption of EEG activity was observed in any of the subjects during the full monitoring period.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	Study was not designed to compare non-invasive method to arterial line, but it does provide data on this.

eAppendix 12 Data abstraction of Dhanani *et al.* 2021

Domain	
Methods	Country: Canada Study aim: To describe the incidence and timing of resumption of cardiac electrical and pulsatile activity in critically ill adults who died after withdrawal of life-sustaining measures. Design: Prospective observational Blinded: No
Population	Study population: ICU WLST with some DCD-eligible patients Includes pediatrics: No Includes MAiD: No Includes DCD: Yes, controlled N (patients): 480 Age, mean/median (SD/Range): Age of 480 pts with waveform review: 65 (15) years
Reference test	Test type: Invasive arterial line Test details: No details on placement. Point of cessation of circulation determined by at least 2 adjudicators. Definition of +/- circulation: Pulse pressure of less than 5 mm Hg for at least 60 seconds.
Comparator test(s) description	Comparator test 1: ECG Test details: Continuous 3-lead electrocardiogram Definition of +/- circulation: Determined by review by at least 2 adjudicators when ECG is isoelectric (flat).
Outcomes for comparator test(s)	**ECG** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: Results indicate a high rate of false negatives for ECG as only 19% of patients had ECG stop within 2 sec of cessation of arterial line. Cessation of cardiac electrical activity coincided within 2 seconds with the last arterial pulse of at least 5 mm Hg in 93 patients (19%). The median time between final arterial pulse and final QRS complex was 3 minutes 37 seconds (range, 0 seconds to 83 minutes 28 seconds). Cardiac electrical activity after the last arterial pulse was observed for more than 30 minutes in 33 of 480 patients (7%) and until the end of recording in 23 of 480 patients (5%).
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	Study was not designed to compare non-invasive method to arterial line, but it does provide comparison of ECG to art line in large pop that includes our target population.

eAppendix 13 Data abstraction of Dick *et al.* 2000

Domain	
Methods	Country: Germany Study aim: To evaluate the diagnostic accuracy and time required by first responders to assess the carotid pulse in potentially pulseless patients. Design: Randomized trial Blinded: Yes
Population	Study population: Adults cardiopulmonary bypass Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 16 Age, mean/median (SD/Range): Pulsatile: 59 (12) years Non-pulsatile: 58 (9) years
Reference test	Test type: Invasive arterial line Test details: No details on placement. Point of cessation of circulation determined by at least 2 adjudicators Definition of +/- circulation: Pulseless = while on cardiopulmonary bypass
Comparator test(s) description	Comparator test 1: Palpable pulse Test details: 1-min carotid pulse check by first responders Definition of +/- circulation: NR
Outcomes for comparator test(s)	**Palpable pulse** Sensitivity: No data for fully trained personnel, 90% for all (n=59) Specificity: 89% for fully trained personnel (n=9), 55% for all, see Table 3 in study for breakdown of other first responders. Definition of sensitivity: n(no pulse palpated, pulseless by reference)/n(pulseless by reference) Definition of specificity: Detecting pulse in patients with pulsatile flow (carotid pulses were present and systolic radial artery pressure was >80 mm Hg) Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: False positive and false negative are not stated by authors but can be calculated from their data. FP: 45% overall FN: 10% for overall
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	Study does not include target population and the population checking pulses was first responders at different training levels. It includes time component to the pulse checks, but findings do indicate that with palpable pulse there is a risk (11% fully trained, 45% overall) of determining that circulation has stopping when it hasn't (false positive).

eAppendix 14 Data abstraction of Genbrugge *et al.* 2017

Domain	
Methods	Country: Belgium Study aim: To explore the regional cerebral oxygen saturation (rSO_2) during the process of dying in Intensive Care Unit (ICU) patients in whom it was decided to withdraw life support. Design: Case series Blinded: No
Population	Study population: ICU patients undergoing withdrawal life support therapy Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 6 Age, mean/median (SD/Range): Mean 64 years, range (53-83)
Reference test	Test type: Invasive arterial line Test details: Arterial catheter in the radial artery Definition of +/- circulation: Not stated but death defined as onset of asystole.
Comparator test(s) description	Comparator test 1: NIRS Test details: Regional cerebral saturation was measured until the patient died using a portable cerebral oximeter (SenSmartTMModel X-100, Nonin Medical Inc, Plymouth, MN, USA and FORE-SIGHTTMtechnology, CASMedical systems, Branford, CT, USA). Baseline rSO_2 value was calculated as mean value over one hour in stable haemodynamic conditions immediately after the decision of withdrawal of life support, before active treatment was stopped. Cerebral saturation values at one hour, 30 min and 15 min before death and at the moment of death were calculated as means of periods of 60 s around these specific time points. Definition of +/- circulation: NR
Outcomes for comparator test(s)	**NIRS** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: The median rSO_2 measured one hour before death was 50% (35%–60%). At the time of death, median rSO_2 was 33% (7%–40%) (Fig. 1). Cerebral saturation and MAP were positively correlated, calculated during the last hour before death was clinically determined (r between 0.722–0.968; $p < 0.01$) (Fig. 3).
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	Population is close to target for controlled DCD and this small case series provides evidence that rSO_2 cannot be used for death determination due to broad range of values at death

eAppendix 15 Data abstraction of Germanoska *et al.* 2018

Domain	
Methods	Country: Australia Study aim: To investigate whether return of pulsatile flow in humans can be reliably assessed by common carotid artery ultrasound. Design: Randomized pilot study Blinded: Yes
Population	Study population: All adult cardiac surgery patients with cardiopulmonary bypass Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 20 patients, 3 physician assessors; 10 had 2D US and 10 had colour US Age, mean/median (SD/Range): median 66 (IQR 60–74 (range 39–84)) years
Reference test	Test type: Invasive arterial line Test details: Waveform of art line and ECG tracings were recorded using a cell phone and time stamped Definition of +/- circulation: No, study was designed to look at return of pulsatile flow. The threshold of MAP for pulsatile flow was not reported.
Comparator test(s) description	Comparator test 1: POCUS Pulse Test details: 2D and colour US measurement of return of pulsatile flow in carotid artery. The US machines used were a Sonosite Mturbo (linear array probe, 13-6 MHz, Brookvale; New South Wales, Australia) and a Philips iE33 (linear array probe,11-3 MHz, Philips Healthcare; North Ryde, Australia) depending on availability. See manuscript for further details on 2D vs colour and on assessor and assessment using US devices. Definition of +/- circulation: Each reviewer watched the videos independently and recorded the timestamp at which they considered pulsatile flow to be first present in the carotid artery. For 2D US this was tissue distortion in the artery wall or surrounding tissue, for colour Doppler this was the colour change within the artery. Comparator test 2: 2D or colour Doppler US Test details: See comparator test 1 Definition of +/- circulation: See comparator test 1
Outcomes for comparator test(s)	**POCUS Pulse** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: The median (interquartile range (range)) mean arterial pressure where ultrasound flow occurred for two-dimensional ultrasound was 62mmHg (49–74 (33–82)) and 56mmHg (52–73 (43–83)) for colour Doppler. In our pilot study, two-dimensional ultrasound was reliable in detecting the return of pulsatile flow. The median difference between radial artery and ultrasound flow time (interquartile range (range)) was 24

	seconds (5–40 (0–93)) for two-dimensional and 5 seconds (2–17 (28 to 188)) for colour Doppler. The intraclass correlation coefficient for two-dimensional ultrasound was 0.86 (95%CI 0.63–0.96) and 0.32 (95%CI 0.01 to 0.71) for colour Doppler **2D or Colour Doppler Ultrasound** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: See comparator test 1
Thresholds	Outcome(s) on threshold for index test: None, but threshold levels of MAP were higher than for death determination Suggested threshold for index test: NR
Other relevant results	Study designed to see if US is better (more rapid and at lower MAP) than palpable pulse for pulse checks and if 2D or colour US better so provides only very indirect evidence for our SR. Main findings are: The median difference between radial artery and ultrasound flow time (interquartile range (range)) was 24 seconds (5–40 (0–93)) for two-dimensional and 5 seconds (2–17 (28 to 188)) for colour Doppler. The intraclass correlation coefficient for two-dimensional ultrasound was 0.86 (95%CI 0.63–0.96) and 0.32 (95%CI 0.01 to 0.71) for colour Doppler. The median (interquartile range (range)) mean arterial pressure where ultrasound flow occurred for two-dimensional images.

eAppendix 16 Data abstraction of Matory *et al.* 2021

Domain	
Methods	Country: USA Study aim: To determine a timeline of events associated with fatal organ failure and to identify EEG signatures associated with those events Design: Retrospective review Blinded: No
Population	Study population: Adult neurological ICU cardiac death Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 19 Age, mean/median (SD/Range): Median 57 (IQR 45–82) years
Reference test	Test type: Cerebral blood flow Test details: Measurement that is based on HR and BP measured by invasive arterial line. Definition of +/- circulation: Cessation of cerebral blood flow (CBF_0) was assumed to occur following a permanent (1) heart rate of less than 20 beats per minute and (2) blood pressure below a set threshold as measured by the arterial line laced into the radial artery. Because blood pressure measures varied in availability between patients, this second criterion was met if at least one of the following subcriteria, as well as all others available, was observed: (2a) mean arterial pressure of less than 20 mm Hg, (2b) systolic blood pressure of less than 40 mm Hg, and (2c) diastolic blood pressure of less than 20 mm Hg. These thresholds were chosen because ventricular asystole [18] and EEG slowing [14] have been observed just below these blood pressure levels.
Comparator test(s) description	Comparator test 1: ECG Test details: ECG recordings were obtained using a digital bedside video monitoring system (XLTEK; Excel-Tech Corp, Natus Medical Incorporated; Oakville, Ontario, Canada; low-pass filter = 70 Hz, highpass filter = 1 Hz, sampling rate = 200, 256, and 512 Hz) Definition of +/- circulation: Last QRS complex (QRS_0) was defined as the time of the final QRS complex with a clear R peak, as recorded on ECG, based on studies of QRS morphology as an indicator of cardiac dysfunction.
Outcomes for comparator test(s)	**NIRS** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: QRS_0 (last QRS) occurred simultaneously or after (up to more than 40 minutes after in 1 case) cessation of cerebral blood flow (CBF_0). See Figure 1. EEG0 occurred at the time of QRS_0 in five patients and after QRS_0 in two patients (cohort median−2.0, interquartile range−8.0 to 0.0), whereas EEG_0 was seen at the time of CBF0

	in six patients and following CBF_0 in 11 patients (cohort median 2.0 min, interquartile range−1.5 to 6.0).
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	Study not designed to compare non-invasive monitoring but provides data on ECG compared to CFB0 which is measured including invasive arterial line and shows that ECG can continue well beyond cessation of circulation.

eAppendix 17 Data abstraction of McNeill *et al.* 2005

Domain	
Methods	Country: Canada Study aim: To analyze cerebral cortical oxygenation during defibrillator threshold testing. Design: Prospective trial Blinded: No
Population	Study population: Adult ICD implantation Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 11 Age, mean/median (SD/Range): 64 ± 11
Reference test	Test type: Induced VF or VT, invasive arterial line present Test details: ECG present. Arterial pressure measured continuously via a catheter placed in the nondominant radial artery. Definition of +/- circulation: Absent circulation when in induced VF or VT. MAP less than 50 mmHg per results, but not defined by this.
Comparator test(s) description	Comparator test 1: NIRS Test details: Indirect measure of cerebral circulation: Cyt a,a3,HbO2, and Hb by NIRS. Hamamatsu NIRO 300 (Hamamatsu Photonics KK, Hamamatsu City, Japan) NIR spectrophotometer. This unit emitted light at four wavelengths (775, 810, 850, and 910 nm) from laser diodes, and directed them into the patient's head and brain from the right of the patient's forehead via a thin fiberoptic bundle attached to the skin by adhesive tape. Monitored continuously. Definition of +/- circulation: NR
Outcomes for comparator test(s)	**NIRS** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: Each episode of VF and VT resulted in a decrease in the mean arterial blood pressure to 23.9 ± 7.5 mmHg ($p \leq 0.05$) and oxyhemoglobin (−4.2 ± 1.7 μmol/L; $p \leq 0.05$) and an increase in de-oxyhemoglobn (2.7 ± 1.4 μmol/L). There was no change in the cytochrome c oxidase copper moiety redox status (0.09 ± 0. 30 μmol/L)
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	Study not designed to compare non-invasive monitoring in population of interest, but it shows that at low MAP, certain indicators of cerebral hypoperfusion by NIRS are not reflective of this low flow state.

eAppendix 18 Data abstraction of Menke *et al.* 2014

Domain	
Methods	Country: Germany Study aim: This study aimed at analyzing the relation of cerebral NIRS readings to vital parameters during CPB surgery in children at a minute scale by using a novel random-coefficient model. Design: Prospective trial Blinded: No
Population	Study population: Children undergoing cardiopulmonary-bypass cardiac surgery Includes pediatrics: Yes Includes MAiD: No Includes DCD: No N (patients): 10 (relevant subgroup of n=4 hypothermic circulatory arrest) Age, mean/median (SD/Range): 6 days to 9 years
Reference test	Test type: Hypothermic circulatory arrest Test details: NR Definition of +/- circulation: NR
Comparator test(s) description	Comparator test 1: NIRS rSO_2 Test details: Forehead, Critikon Cerebral RedOx Monitor 2020; Johnson & Johnson Medical, UK. Definition of +/- circulation: NR
Outcomes for comparator test(s)	**NIRS** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: Extracted data from Figure 2, initial NIRS was 54-69%, and nadir 51-59%. "With some interindividual differences, the nadir of complete cerebral rSO_2 deployment was estimated as 46.7–52.9 %. Patients no. 3, 8, and 9 started at a relatively high rSO_2 of 64–69 %, with consequently high rSO_2 reserve, and did not reach their estimated nadir during circulatory arrest (Fig. 2). In these three patients, the half-life T1/2 of the exponential rSO_2 decay ranged from 5.2 to 9.0 min."
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	Study not designed to compare non-invasive monitoring in population of interest but it shows that at low MAP, certain indicators of cerebral hypoperfusion by NIRS are not reflective of this low flow state

eAppendix 19 Data abstraction of Sanchez *et al.* 2020

Domain	
Methods	Country: Australia Study aim: To conduct a diagnostic accuracy study of 2D ultrasound of the carotid artery for detection of the presence or absence of a pulse Design: Prospective trial Blinded: Yes
Population	Study population: Adults undergoing cardiopulmonary bypass cardiac surgery Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 23 Age, mean/median (SD/Range): Median 64 (IQR 14) years
Reference test	Test type: Invasive arterial line Test details: No details on placement. Definition of +/- circulation: "the presence/absence of an arterial waveform"
Comparator test(s) description	Comparator test 1: POCUS Pulse Test details: Carotid pule 2D Ultrasound. A researcher recorded the carotid artery ultrasound videos intra-operatively, which were then later read by critical care physicians from anaesthetic, emergency, and ICU. Definition of +/- circulation: As read by physician. Training videos used beforehand for physicians.
Outcomes for comparator test(s)	**POCUS Pulse** Sensitivity: 91% (95% CI 0.89-0.93) Specificity: 90% (95% CI 0.86-0.93) Definition of sensitivity: Sensitivity= n (pulse detected by POCUS, pulse present by art line)/ n(pulse present by art line). Definition of specificity: Specificty = n (pulse absent by POCUS, pulse absent by art line)/ n(pulse absent by art line) Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: Sensitivity was highest in the high-SBP group (>90mmHg) (0.96, 95% CI 0.93 0.98) and lowest in the low-SBP group (<70 mmHg) (0.83, 95% CI 0.78 0.87).
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	Study does not include target population. Study is designed for diagnostic accuracy. Physician readers of test are reading pre-recorded videos done by someone else at a different time.

eAppendix 20 Data abstraction of Sarti *et al.* 2006

Domain	
Methods	Country: Italy Study aim: Compared the performance of three sites of pulse palpation (brachial, carotid, and femoral) for detecting and counting heartbeat in hypotensive infants. Design: Prospective trial Blinded: Yes
Population	Study population: Intraoperative infants Includes pediatrics: Yes Includes MAiD: No Includes DCD: No N (patients): 40 Age, mean/median (SD/Range): Mean 5.6 (SD 3.7) months
Reference test	Test type: Invasive arterial line Test details: Radial artery Definition of +/- circulation: No true cessation of circulation. Categorized as hypotensive or normotensive.
Comparator test(s) description	Comparator test 1: Palpable pulse Test details: Examiners (2 MD, 2 RN) had 10 s to find the pulse at three sites (brachial, femoral, carotid). Definition of +/- circulation: As palpated pulse or no pulse.
Outcomes for comparator test(s)	**POCUS Pulse** Sensitivity: NR Specificity: Brachial 41%, femoral 65%, carotid 52% Definition of sensitivity: n(pulse detected by POCUS, pulse present by art line)/ n(pulse present by art line). Definition of specificity: n(pulse by palpation, pulse on arterial line) / n(pulse on arterial line) Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: Additional data for time to detection in Table 1. Overall agreement among the four observers was poor for femoral and carotid pulse detection (k=0.178 and 0.118, respectively) and fair for brachial pulse detection (k=0.221).
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	Study does not include target population. Study is designed for diagnostic accuracy.

eAppendix 21 Data abstraction of Schonberger *et al.* 2014

Domain	
Methods	Country: USA Study aim: To assess possibilities for improving the detection of the return of spontaneous circulation during in-hospital resuscitation. Design: Case series Blinded: No
Population	Study population: Adult cardiac arrest Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 8 Age, mean/median (SD/Range): Calculated mean 62.3 years, reported range 35-79 years
Reference test	Test type: Palpable pulse Test details: Site of pulse check not dictated. Definition of +/- circulation: positive/negative pulse
Comparator test(s) description	Comparator test 1: POCUS Pulse Test details: Doppler US, femoral location, Dipplex D900 Probe Definition of +/- circulation: NR
Outcomes for comparator test(s)	**POCUS Pulse** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: Doppler-positive-palpation-negative pulse checks occurred in five of eight cases for an estimated incidence of 62.5% (95% CI, 29 to 96%). In 1/5 discordant cases, a radial artery catheter was successfully placed before repeating manual pulse check occurred, confirming pulsatile flow.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	None.

eAppendix 22 Data abstraction of Schramm *et al.* 2013

Domain	
Methods	Country: Germany Study aim: To compare CNAP and IAP. Design: Prospective trial Blinded: No
Population	Study population: Adult intraoperative Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 33 Age, mean/median (SD/Range): Mean 82 (SD 4) years
Reference test	Test type: Invasive arterial line Test details: 20-gage, radial location Definition of +/- circulation: Absence of circulation during rapid ventricular pacing (180-200 per minute), blood pressure described as "approximately 40 mmHg", but no cut off given.
Comparator test(s) description	Comparator test 1: CNAP Test details: CNAP™ (CNSystems Medizintechnik, Graz, Austria). this device monitors blood flow into the finger and translates blood flow oscillations sensed by encircling finger cuffs into a continuous pulse pressure waveform and beat-to-beat values of arterial blood pressure Definition of +/- circulation: NR
Outcomes for comparator test(s)	**CNAP** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: Overall CNAP accuracy (bias), calculated by subtracting IAP from CNAP, was −6.3 ± 18.9, 7.4 ± 10.5, and 4.0 ± 11.3 mmHg (mean ± SD, systolic, diastolic, and mean). Bias increased during episodes of severe hypotension to 11.8 ± 14.5, 13.8 ± 12.4, and 12.9 ± 12.4 mmHg. The percentage of agreements (95% confidence interval) between the blood pressure pairs with a difference ≤15 mmHg was 58.5% (57.9–58.6), 75.8% (75.5–76.0), 82.2% (81.9–82.4; systolic, diastolic, mean) for all data and 56.4% (54.2–58.9; P = 0.71), 53.2%* (51.1–56.0), and 57.4%* (56.3–59.1; *P < 0.001) during rapid pacing.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	None.

eAppendix 23 Data abstraction of Schwarz *et al.* 1996

Domain	
Methods	Country: Austria Study aim: To test whether INVOS 3100 adequately responds to completely abolished perfusion of cerebral an extracerebral structures. Design: Case-control Blinded: No
Population	Study population: Dead adults and healthy volunteers Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 18 dead, 15 volunteers (total n=33) Age, mean/median (SD/Range): Dead patients: Mean 74.4 (SD 14.6) years Healthy volunteers: Mean 34.2 (SD 8.7) years
Reference test	Test type: Clinical death exam, nothing for healthy volunteers Test details: "Death was defined by irreversible cessation of heart and respiratory activity, loss of spontaneous motor movements and ophthalmic brainstem reflexes, and by the presence of livor mortis." Definition of +/- circulation: Absence of circulation if dead. Present if healthy.
Comparator test(s) description	Comparator test 1: NIRS Test details: INVOS 3100 near-infrared Cerebral Oximeter (Somanetics, USA), forehead prepped with dry cloth, skin prep swab, applied sensor so that a lateral margin of the sensor was at the midline of the forehead and the lower margin was 2cm above the eyebrows. Measurements repeated until at least 5 consecutive constant values were obtained. Definition of +/- circulation: NR
Outcomes for comparator test(s)	**NIRS** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: Table 2 in the study lists all rSO_2 values in dead subjects. Values ranged from 6-88% in dead subjects, and 60 to 76 in healthy volunteers. The mean of the two groups differed ((cases 51.0% (26.8) vs. controls 68.4% (5.2); p-0.029 Mann-Whitney rank sum test), but six of the 18 dead subjects had rSO_2 values at or above 60% (above the lowest values seen in normal controls). No threshold suggested.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	None.

eAppendix 24 Data abstraction of Simard *et al.* 2019

Domain	
Methods	Country: Canada Study aim: To describe a simple, novel technique for rapidly and accurately detecting the presence of a central pulse using POCUS for patients in cardiac arrest. Design: Case series Blinded: No
Population	Study population: Adult cardiac arrest Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 4 Age, mean/median (SD/Range): Calculated mean 62 years, reported range 20-87 years
Reference test	Test type: Palpable pulse Test details: NR Definition of +/- circulation: Absence or presence of pulse
Comparator test(s) description	Comparator test 1: POCUS Pulse Test details: NR Definition of +/- circulation: present circulation = non-compressible artery and pulsatile, absent = compressible artery
Outcomes for comparator test(s)	**POCUS Pulse** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: Case 1, 3 and 4 describe a palpation-no pulse POCUS-positive pulse. Case 2 describes a palpation-indeterminate, POCUS-indeterminate then POCUS-no pulse.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	None.

eAppendix 25 Data abstraction of Slavin *et al.* 1994

Domain	
Methods	Country: USA Study aim: To describe a simple, novel technique for rapidly and accurately detecting the presence of a central pulse using POCUS for patients in cardiac arrest. Design: Case series Blinded: No
Population	Study population: Adult cardiac death Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 1 Age, mean/median (SD/Range): 64 years old
Reference test	Test type: Death/"heart stopped" Test details: NR Definition of +/- circulation: NR
Comparator test(s) description	Comparator test 1: NIRS Test details: Somanetics INVOS 3100 cerebral oximeter, attached to forehead with self-adhesive material, recordings from one or both sides of a patient's forehead, recorded every 10-11 seconds. Definition of +/- circulation: NR
Outcomes for comparator test(s)	**POCUS Pulse** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: NR Reported false negative: NR Reported false positive: NR Definition of false negative: NR Definition of false positive: NR Additional details: The initial value of rSO_2 was quite low.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	None.

eAppendix 26 Data abstraction of Tibballs *et al.* 2010

Domain	
Methods	Country: Australia Study aim: To determine time and accuracy diagnosing paediatric cardiac arrest (CA) by pulse palpation. Design: Prospective trial Blinded: Yes
Population	Study population: Children in ICU on ECLS and/or cardiac failure Includes pediatrics: Yes Includes MAiD: No Includes DCD: No N (patients): 17 Age, mean/median (SD/Range): Range of 1 day to 11 years.
Reference test	Test type: Invasive arterial line and 'unhurried palpation' Test details: The presence or absence of a true pulse was determined by the investigators and the bedside nurse using unhurried palpation and observation of invasively monitored blood pressure and pulse pressure (if any). In results, they specify that all patients had arterial lines. Definition of +/- circulation: Research team decision, no defined pulse pressure.
Comparator test(s) description	Comparator test 1: Palpable pulse Test details: Doctor or nurse (153 total, 14 repeat from previous study). Rescuers were instructed to palpate the brachial pulse on the side opposite the deployment of the ECLS apparatus (for ease of access) and to decide if pulse was present or absent Definition of +/- circulation: Present/absent palpable pulse
Outcomes for comparator test(s)	**Palpable pulse** Sensitivity: 76 (95% CI 64-86) Specificity: 79% (95% CI 0.69-0.86) Definition of sensitivity: In this study in which the disease is cardiac arrest, the positive test which confirms it is the absence of a pulse. Thus, when no true pulse was present, rescuer responses were classified as either true positive (TP) ("pulse absent") or false negative (FN) ("pulse present"). When a true pulse was present, rescuer response were classified as either true negative (TN) ("pulse present") or false positive (FP) ("pulse absent"). Sensitivity (TP/(TP + FN), specificity (TN/(TN + FP) and accuracy of responses (TP + TN/total) were calculated Definition of specificity: See "Definition of sensitivity". Reported false negative: 13/55 Reported false positive: 21/98 Definition of false negative: See "Definition of sensitivity". Definition of false positive: See "Definition of sensitivity". Additional details: CA on 55 occasions was diagnosed by 42 (76%) rescuers in mean (±SD) time 30 ± 19 s. Experienced rescuers diagnosed CA in 25 ± 14 s, inexperienced rescuers in 37 ± 24 s ($p = 0.042$). CA absent on 98 occasions was confirmed by 77 (79%) rescuers in 13 ± 13 s. Experienced rescuers confirmed absent CA in 9 ± 5 s, inexperienced rescuers in 21 ± 19 s ($p = 0.0001$). Diagnosis of CA compared to confirmation of absence took longer by all rescuers ($p < 0.0001$), experienced rescuers ($p < 0.0001$) and

	inexperienced rescuers (p = 0.018). 28 of 33 (85%) experienced doctors diagnosed CA or confirmed absence in 13 ± 9 s, 49 of 61 (80%) experienced nurses in 15 ± 12 s, 11 of 21 (52%) inexperienced nurses in 18 ± 15 s and 31 of 38 (82%) inexperienced doctors in 30 ± 24 s.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	None.

eAppendix 27 Data abstraction of Tibballs *et al.* 2009

Domain	
Methods	Country: Australia Study aim: To determine the reliability of pulse palpation to diagnose paediatric cardiac arrest. Design: Prospective trial Blinded: Yes
Population	Study population: Children in ICU on ECLS and/or cardiac failure Includes pediatrics: Yes Includes MAiD: No Includes DCD: No N (patients): 16 Age, mean/median (SD/Range): Mean 1.8 years, range (1 week to 13 years)
Reference test	Test type: Invasive arterial line and "unhurried palpation" Test details: The presence or absence of a true pulse was determined by the investigators and the bedside nurse using unhurried palpation and observation of invasively monitored blood pressure and pulse pressure (if any). In the results, they specify that all patients had arterial lines. Definition of +/- circulation: Research team decision, no defined pulse pressure
Comparator test(s) description	Comparator test 1: Palpable pulse Test details: Doctor or nurse (209 total). Rescuers were instructed to palpate any pulse of their choice excluding the cardiac apex, and to attempt a decision of "pulse present" or "pulse absent" within 10s Definition of +/- circulation: Present/absent palpable pulse
Outcomes for comparator test(s)	**Palpable pulse** Sensitivity: 86% (95% CI 77-90) Specificity: 64% (95% CI 53-74) Definition of sensitivity: Rescuers responses were classified as either true positive (TP) ("pulse absent") or false negative (FN) ("pulse present") when a true pulse was absent, and as either true negative (TN) ("pulse present") or false positive (FP) ("pulse absent") when a true pulse was present. Sensitivity TP/(TP + FN), specificity TN/(TN + FP) and accuracy of responses TP + TN/total). Definition of specificity: See "Definition of sensitivity". Reported false negative: 18/128 Reported false positive: 29/81 Definition of false negative: See "Definition of sensitivity". Definition of false positive: See "Definition of sensitivity". Additional details: When investigators diagnosed cardiac arrest pulse pressure was 6 ± 5 mmHg (range 0–20) compared with 9 ± 8 mmHg (range 0–29) with rescuers (p = 0.0004). With pulse pressure zero, rescuer accuracy was 89% and sensitivity 0.89. Sixty per cent of rescuers chose a brachial pulse, 33% a femoral pulse with respective accuracies of 78% and 77%, sensitivities 0.86 and 0.85 and specificities 0.67 and 0.56.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant	None.

results	

eAppendix 28 Data abstraction of Zengin *et al.* 2018

Domain	
Methods	Country: Turkey Study aim: To compare the efficiency of cardiac ultrasonography (CUSG), Doppler ultrasonography (DUSG), and manual pulse palpation methods to check the pulse in CA patients. Design: Prospective observational Blinded: Not stated as blinded. Curtain used between US/pulse check.
Population	Study population: Adult cardiopulmonary arrest ED Includes pediatrics: No Includes MAiD: No Includes DCD: No N (patients): 137 patients, 2 doctors performing US Age, mean/median (SD/Range): Mean 63.4 (SD 16.8) years
Reference test	Test type: Cardiac US Test details: max 10 s Definition of +/- circulation: "cardiac kinetic motion" = present circulation
Comparator test(s) description	Comparator test 1: Palpable pulse Test details: Max 10s between pulse checks, femoral Definition of +/- circulation: Present/absent palpable pulse Comparator test 2: POCUS Pulse Test details: Doppler US femoral, max 10s between pulse checks Definition of +/- circulation: NR
Outcomes for comparator test(s)	**Palpable pulse** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: See "Definition of sensitivity". Reported false negative: False negative 100%, 28% and 0% at first, second and last pulse checks. Reported false positive: False-positive 5.3%, 3.5% and 0% at first, second and last pulse checks. Definition of false negative: n(no pulse palpated, CUS positive movement)/n(CUS positive movement) Definition of false positive: n(pulse palpated, CUS no movement/n(CUS no movement) Additional details: CUS used as gold-standard. Full data available in Table 2 in study. **POCUS Pulse** Sensitivity: NR Specificity: NR Definition of sensitivity: NR Definition of specificity: See "Definition of sensitivity" Reported false negative: False-negative 28.5%, 12% and 10.3% at first, second and last check.

	Reported false positive: False-positive 0.7%, 2.6%, 0.9% at first, second and last check Definition of false negative: n(no Doppler pulse present, CUS positive movement)/n(CUS(positive movement)) Definition of false positive: n(Doppler pulse present, CUS no movement)/n(CUS no movement) Additional details: CUS used as gold-standard. Full data available in Table 2 in study.
Thresholds	Outcome(s) on threshold for index test: NR Suggested threshold for index test: NR
Other relevant results	None.

2D = two-dimensional; CA = cardiac arrest; CI = confidence interval; CNAP = continuous non-invasive arterial pressure; DCD = donation after circulatory death; ECG = electrocaradiogram; ECLS = extracorporeal life support; ED/ER = emergency department/room; EEG = electroencephalogram; EF = ejection fraction; IAP = invasive arterial pressure; ICU = intensive care unit; IQR = interquartile range; MAiD = medical assistance in dying; NIRS=near-infrared spectroscopy; NR = not reported; PICU = pediatric intensive care unit; POCUS=point-of-care ultrasound; SD = standard deviation; US = ultrasound/ultrasonography; UT = ultrasound-tagged; VF = ventricular fribillation; VT = ventricular tachycardia; WLST = withdrawal of life-sustaining therapy