Supplementary material

Gallina T, Żuławińska B, Stępniewski J, et al. Recognition of emerging cardiac diagnoses by echocardiography in 5th-year medical students — the role of focused e-learning. Kardiol Pol. 2021.

Supplementary Methods 1

Distractors to questions about echocardiographic images

Correct answer	Other distractors*
Acute aortic dissection	Restrictive cardiomyopathy Severe systolic dysfunction of the left ventricle Cardiac tamponade
Acute pulmonary embolism	Infective endocarditis Cardiac tamponade Thrombus in the left ventricle
Acute myocardial infarction	Cardiac tamponade Myocarditis Acute pulmonary embolism
Cardiac tamponade	Heart aneurysms Fluid in pericardium without tamponade Mitral valve regurgitation
Infective endocarditis	Acute myocardial infarction Acute aortic dissection Cardiac tamponade
Mitral valve regurgitation	Aortic valve regurgitation

	Tricuspid valve regurgitation Pulmonary valve regurgitation
Severe systolic dysfunction of the left ventricle	Acute pulmonary embolism Restrictive cardiomyopathy Cardiac tamponade
Thrombus in the left ventricle	Acute myocardial infarction Acute pulmonary embolism Severe systolic dysfunction of the left ventricle

*I do not know answer was possible in each question

Distractors to echocardiographic descriptions

Correct answer	Other distractors (and in each question "I don't' know")
Acute pulmonary embolism	Acute myocardial infarction of the right ventricle Severe systolic dysfunction of the left ventricle Dilated cardiomyopathy
Acute myocardial infarction	Severe aortic valve stenosis Acute aortic dissection Acute pulmonary embolism
Cardiac tamponade	Myocarditis Severe systolic dysfunction of the left ventricle with pericardium leakage

	Fluid in the pericardium without tamponade
High risk of pulmonary hypertension	Cardiac tamponade Acute myocardial infarction of the right ventricle Severe aortic valve stenosis
Infective endocarditis	Restrictive cardiomyopathy Acute aortic dissection Severe aortic valve stenosis
Severe aortic valve stenosis	Hypertrophic cardiomyopathy High risk of pulmonary hypertension Restrictive cardiomyopathy
Severe systolic dysfunction of the left ventricle	Hypertrophic cardiomyopathy Severe aortic valve stenosis Acute pulmonary embolism
Thrombus in the left ventricle	Acute pulmonary embolism Myxoma Infective endocarditis

Echocardiographic descriptions

1. **Acute pulmonary embolism**

LV: 45/20, EF: 60%, E/A = 1, E/E' = 3,8, LA: 15 cm^2

aortic valve: gradient 6/3 mmHg, normal size of aorta

mitral valve: gradient 2/1 mmHg, mild mitral regurgitation;

RA: 23 cm^2, TAPSE: 12 mm, RVD1: 60 mm, RV/LV = 1,3/1;

pulmonary valve: gradient 6/3 mmHg, AcT: 40 ms (shortened), widened pulmonary trunk;

tricuspid valve: mild tricuspid regurgitation, RVSP: 43, IVC: 25 mm, without respiratory response

2. **Acute myocardial infarction**

LV: 48/34 mm, wall thickness 9/12 mm, EF: 42% E/A = 0,7, E/E' = 5,5, LA: 13 cm^2;

aortic valve: bicuspid, gradient 6/3 mmHg, calcified cusps, ascending aorta 33 mm;

mitral valve: gradient 2/1 mmHg, mild mitral regurgitation;

RA: 14 cm^2, TAPSE: 25 mm;

tricuspid valve: mild tricuspid regurgitation, RVSP: 27, IVC: 11 mm, with normal respiratory response;

apical, anterior and septolateral hypo/akinesia.

3. **Cardiac tamponade**

LV: 46/32 mm, wall thickness 10/13 mm, EF: 65%, E/A = 0,9;

Heart valves without significant pathologies.

RA: 13 cm^2, IVC: 22 mm, without respiratory response;

Fluid is visible in the pericardium, in diastole there is a layer of liquid in front of the right ventricle 16 mm, behind the left ventricle 15 mm. Collapsing> 1/3 right atrium, partial collapse of the free right ventricular wall in diastole. Respiratory variability of the tricuspid flow.

4. **High risk of pulmonary hypertension**

LV: 32/19 mm, wall thickness 8/14 mm, EF: 75%, E/A = 0,7, E/E' = 4,4, LA: 13,5 cm^2;

aortic valve: tricuspid, gradient 3/2 mmHg, ascending aorta 22 mm;

mitral valve: gradient 4/2 mmHg;

RA: 26,4 cm^2, TAPSE: 15 mm, RVD1: 51 mm;

pulmonary valve: gradient 3/2 mmHg, widened pulmonary trunk, AcT: 80 ms, mild pulmonary regurgitation;

tricuspid valve: moderate tricuspid regurgitation, RVSP: 130, IVC: 19 mm, without respiratory response.

Fluid in the pericardial sac around the right ventricle 7-9 mm thick, no signs of a tamponade.

5. **Infective endocarditis**

LV: 77/44 mm, wall thickness 10/19 mm, EF: 72%, LA: 19 cm^2

aortic valve: bicuspid, gradient 38/25 mmHg, moderate aortic regurgitation, calcified cusps, additional mobile structures visible on the aortic cusps, ascending aorta 34 mm;

mitral valve: gradient 6/4 mmHg;

RA: 19 cm^2

There is additional space in the area of the aortic valve communicating with the aortic lumen.

6. **Severe aortic valve stenosis**

LV: 50/36 mm, wall thickness 18/26 mm, EF: 55%, grade 3 diastolic dysfunction

(E/A = 1,5; E/E' = 20), LA: 32 cm^2

aortic valve: bicuspid, gradient 67/38 mmHg, AVA: 0,72 cm^2, calcified cusps, ascending aorta 37 mm;

mitral valve: gradient 4/2 mmHg, mild/moderate mitral regurgitation;

RV: normal size, TAPSE: 27 mm, RA: 19,8 cm^2

tricuspid valve: mild tricuspid regurgitation, RVSP: 22, IVC: 14 mm, with normal respiratory response.

7. **Severe heart failure**

LV: 73/65 mm, wall thickness 9/12 mm, EF: 25%, LA: 44 cm^2;

aortic valve: tricuspid, gradient 10/5 mmHg, thickened cusps, ascending aorta 37 mm

mitral valve: gradient 2,7/1 mmHg, severe mitral regurgitation;

RA: 35 cm^2, TAPSE: 15 mm;

tricuspid valve: severe tricuspid regurgitation, RVSP: 67 mmHg, IVC: 26 mm, without respiratory response

septal hypokinesis, inferior wall akinesia.

8. **Thrombus in left ventricle**

LV: 59/42 mm, wall thickness 10/15 mm, EF: 47%, E/A = 0,5, E/E' = 4, LA: 22 cm^2, grade 1 diastolic dysfunction;

RA: 24 cm^2, TAPSE: 24 mm;

tricuspid valve: mild tricuspid regurgitation, RVSP: 23, IVC: 16 mm, with normal respiratory response.

Akinesis of apical segments, septal and anterior wall hypokinesia. In the apex, an additional well-saturated structure measured 22x13 mm with slide outlines.

Abbreviations:

AcT - pulmonary ejection acceleration time, AVA - aortic valve area, E/A - early to late diastolic transmitral flow velocity, E/E' - early diastolic mitral annular tissue velocity, EF - ejection fraction, IVC - inferior *vena cava*, LA - left atrium, LV - left ventricle, RA - right atrium, RVD1 - right ventricular *basal* diameter, RVSP - right ventricular systolic pressure, TAPSE - tricuspid annular plane systolic excursion.

Supplementary Methods 2

Sample size calculation

The sample size was predefined based on a study by Salerno A et al. (J Emerg Med. 2020;58:947-9521) who compared the knowledge of transesophageal echocardiography before and after a course combining interactive e-learning and hands-on simulation. The proportion of students who significantly improved knowledge to pass the a multiple-choice test improved

from 40% on the pre-course test to 80% on the post-course test. Accordingly, in our study we assumed that at least 80% of students in the post-course group and no more than 40% of students in the control group would be able to pass the final test. For an alfa level of 0.05 and beta level of 0.2, the minimal number of students in each group was calculated as 22. Therefore we decided to stop enrollment to our study when the number of students who completed the test and who met the inclusion criteria was 25 in each group.

Supplementary Discussion 1

Summary of previous publication about on-line teaching of echocardiography:

Publication	Subjects	Study characteristics
Our study	**50**	**Type of course**: on-line, synchronous courses including: theory, discussion and active case presentations **Participants**: 5th year medical students **Course materials**: basic knowledge about echocardiography and emergency cardiac condition **Assessment method**: on-line test to check the ability to make the wright diagnosis based on echo imaging and to interpret a description of echocardiographic description
Salerno A, et al. J Emerg Med. 2020 [1]	15-42 depending on the part of the study	**Type of course**: e-learning and hands-on simulation **Participants**: emergency physicians and medical intensive care unit fellows **Course materials**: transesophageal echocardiography **Assessment methods**: a multiple-choice test of knowledge

Kailin JA et al. Pediatr Cardiol. 2021 [2]	**124**	**Type of course**: online learning combined with lecture-based and hands-on teaching **Participants**: cardiology and critical care fellows national and international participants recruited from an online echo education website **Course materials**: online learning modules and a 3-day training program with hands-on workshops and didactic lectures **Assessment method**: 80-question pre and post-test multiple choice exams
Mitchell JD et. al. J Cardiothorac Vasc Anesth. 2015 [3]	**33**	**Type of course**: online modules and live teaching vs to a live-teaching-only **Participants**: anesthesia trainees **Course materials**: transesophageal echocardiography **Assessment methods**: 80-question pre and post-test multiple choice exams
Weber U. et al. Medicine 2019 [4]	**51**	**Type of course**: tutorial about theoretical knowledge followed by 2 practical study sessions either by e-learning using an online simulator with the simulation mannequin or in the operating room **Participants**: anesthesia and intensive care residents **Course materials**: transesophageal echocardiography **Assessment methods**: practical and theoretical exam

Torabi AJ, et al. Echocardiography. 2021[5]	127	**Type of course**: self-directing classes on e-Learning software **Participants**: 2nd year medical students **Course materials**: echocardiography anatomy **Assessment methods**: post-course multichoice exam

Supplementary references

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2. Kailin JA, Kyle WB, Altman CA, Wood AC, Schlingmann TS. Online Learning and Echocardiography Boot Camp: Innovative Learning Platforms Promoting Blended Learning and Competency in Pediatric Echocardiography. Pediatr Cardiol. 2021 Feb;42(2):389-396. doi: 10.1007/s00246-020-02494-w. Epub 2020 Nov 11. PMID: 33179179.
3. Mitchell JD, Mahmood F, Wong V, Bose R, Nicolai DA, Wang A, Hess PE, Matyal R. Teaching concepts of transesophageal echocardiography via Web-based modules. J Cardiothorac Vasc Anesth. 2015 Apr;29(2):402-9. doi: 10.1053/j.jvca.2014.07.021. Epub 2014 Nov 14. PMID: 25440653.
4. Weber U, Zapletal B, Base E, Hambrusch M, Ristl R, Mora B. Resident performance in basic perioperative transesophageal echocardiography: Comparing 3 teaching methods in a randomized controlled trial. Medicine (Baltimore). 2019 Sep;98(36):e17072. doi: 10.1097/MD.0000000000017072. PMID: 31490407; PMCID: PMC6738965.

5. Torabi AJ, Feigenbaum H, Bateman PV. Introducing echocardiography to medical students: A novel echocardiography E-Learning experience. Echocardiography. 2021 Apr;38(4):549-554. doi: 10.1111/echo.15013. Epub 2021 Mar 1. PMID: 33650107.