

Analysis of 1-year Consecutive Application with Focused Transthoracic Echocardiography in Noncardiac Surgery

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Point-of-care transthoracic echocardiography (TTE) is an evolving field in anesthesia field and verified to have the potential to provide rapid diagnostic information during the hemodynamic collapse in operating room.^[1] In this retrospective observatory study, we retrieved all the data of 1-year consecutive use of intraoperative echocardiography in patients with circulatory collapse or undergoing selective high-risk noncardiac surgery.

There were 17 out of over 30,000 surgical cases receiving echocardiographic examinations in our department from May 2016 to May 2017. Preoperative TTE screening was performed in nine cases on the day of surgery, which yielded three cancellations of surgery due to the new findings including unilateral massive pleural effusion, severely depressed left ventricular (LV) contractility (ejection fraction <20%), or cancer embolus in inferior vena cava (IVC) cephalad migrating to second portal of liver. One patient was preoperatively diagnosed with hypertrophied obstructive cardiomyopathy with dynamic LV outflow tract (LVOT) obstruction. However, our examination demonstrated the maximal pressure gradient across LVOT of 25 mmHg (1 mmHg = 0.133 kPa) following Valsalva maneuver. The patient received the mastectomy surgery uneventfully with judicious titration of LV volume and contractility [Supplementary Table 1]. Eight transthoracic echocardiographic examinations were performed in the emergency with seven cases intraoperatively and one case in Intensive Care Unit (ICU) ward postoperatively owing to severe hypoxia [Supplementary Table 1, from patient 10 to patient 17]. The leading causes associated with intraoperative cardiovascular collapse were cardiogenic shock including global or regional LV contractility depression, vasoplegia, followed by hypovolemic shock and flash pulmonary edema complicated with severe mitral valve stenosis and atrial fibrillation with rapid ventricular rhythm. All the patients got

full recovery from illness and discharged from hospital except one died of malignant ventricular arrhythmia immediately after transferring into ICU. No neurologic lesion was reported in 16 patients after 1-month follow-up.

High-risk patients received preoperative superficial thoracic ultrasound screening, which led to three cancellations of surgery comprising of an unplanned surgical intervention and four significant alterations in anesthetic induction approaches or hemodynamic management. We found that focused TTE performed in the operation room feasible and frequently altered anesthetic management. Notably, this study reiterates the significance that anesthesiologist-operational focused echocardiographic examination elicited a beneficial effect on seeking the clue of severe hypotension and guiding the management for patients with circulatory collapse. First, it can promptly exclude the apparent etiologies leading to circulatory collapse. Two elderly patients suffered the circulatory collapse in total knee/hip replacement surgery, and pulmonary embolism would be an immediately obvious cause to spring to mind in the situation. However, TTE did not identify any thrombi travel in the right heart, pulmonary trunk but also could not find any evidence supporting right ventricle strain. Second, point-of-care TTE is a useful modality to identify the ventricle contractility or intracardiac anatomic aberrancy in valve or pericardium with two-dimensional or

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color modality. Third, IVC collapsibility in patients under mechanic ventilation is a relatively more reliable predictive indicator for fluid responsiveness than static pressure-based variables.^[2] However, high IVC collapsibility cannot differentiate hypovolemic shock from distributive shock. Blanco advocated the addition of ultrasound calculation of stroke volume or surrogates to the rapid ultrasound assessment for shock (RUSH protocol) and provided the support for its utility in the differential diagnosis of these two distinct categories of shock.^[3] In this study, hemodynamic evaluation with velocity time integral (VTI) of LVOT blood flow was helpful in determining the types of shock [Supplementary Figure 1]. The patients within or above the normal range of VTI (18–22 cm) concomitant with high collapsibility of IVC can be ascribed to the vasoplegic syndrome requiring high dose of vasoconstrictor to maintain the blood pressure, whereas those below normal VTI are definitive diagnosis of hypovolemic shock and responsive to fluid loading. Albeit TEE is proven to be effective in rapid assessment during intraoperative hemodynamic compromise in the multitude of studies, it is minimally invasive and not without risk, with recent data suggesting a 1:1000 incidence of gastroesophageal injury and a 1:5000 incidence of death.^[4] By contrast, TTE is relatively noninvasive, takes less time to conduct the examination and indicated for awake patients.

Despite clearly altering patient management using point-of-care TTE, it is unclear whether these changes actually influenced and improved the patient outcome compared with empiric treatment since we unexceptionally conducted rapid ultrasound assessment protocol for patients in the crisis with the wide use of ultrasound machine in our department.^[5] Notably, all the patients in the present study got full recovery from illness and discharged from hospital except one died of malignant ventricular arrhythmia immediately after transferring into ICU. No neurologic lesion was reported in 16 patients after 1-month follow-up. It might be highly related to accurate diagnosis and prompt intervention under the guidance of ultrasound examination. Therefore, our practice in this field implicated that point-of-care TTE accompanied with quantitative analysis of VTI of LVOT provided invaluable information and real-time images of cardiac structure to interpret the pathophysiological alteration associated with those critical events.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s)/patient's guardians has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients/patient's guardians understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Supplementary information is linked to the online version of the paper on the Chinese Medical Journal website.

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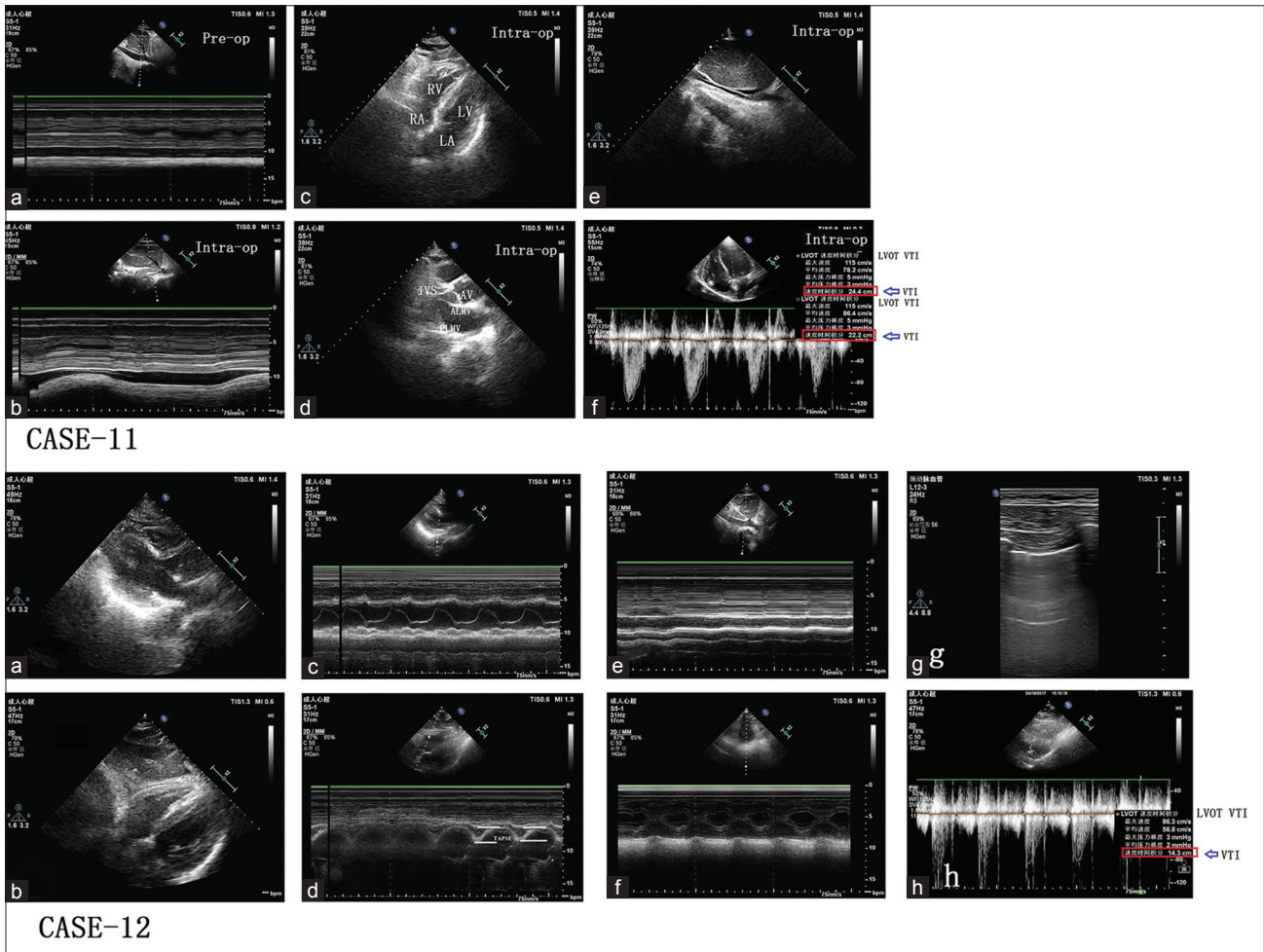
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Conflicts of interest

There are no conflicts of interest.

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Supplementary Figure 1: The integrating of the calculation of VTI of LVOT in rapid ultrasound assessment in shock. The upper panel images were from Case No 11. (a and b) Increased IVC respiration variation and decreased in IVC dimension in (e) during the period of intraoperative hemodynamic collapse. (c and d) Parasternal LAX and Subxiphoid views indicated well-preserved left ventricular contractility (anterior leaflet of mitral valve slapping the intraventricular septum in d) and excluded the occurrence of pulmonary embolism and pericardium tamponade in c. (f) The VTI of LVOT was above the normal range of 16–22 cm. The lower panel images were from Case No 12. (a-c) Parasternal LAX view indicated well-preserved ventricular contractility (anterior leaflet of mitral valve slapping the intraventricular septum in a from two-dimensional modality, c from M modality, respectively) and excluded the occurrence of pulmonary embolism and tamponade from subxiphoid view in b; (d) the right ventricular systolic function was preserved with tricuspid annular plane systolic excursion over 20 mm; (e) IVC respiration variation; (f) parasternal SAX view at papillary muscle level indicated left ventricular volume deficit shown as “Kiss sign;” g: lung sliding and A lines were shown in g excluded the occurrence of pneumothorax and pulmonary edema; (h) the VTI of LVOT was below the normal lower limit of 16 cm. IVC: Inferior vena cava; VTI: Velocity time interval; LVOT: Left ventricular outflow tract; LAX: Long axis; SAX: Short axis; RV: Right ventricle; LV: Left ventricle; RA: Right atrium; LA: Left atrium; AV: Aortic valve; IVS: Interventricular septum; ALMV: Anterior leaflet of mitral valve; PLMV: Posterior leaflet of mitral valve.

Supplementary Table 1: The coexisting disease, TTE new finding, and alteration of anesthetic management in patients receiving preoperative TTE and the diagnosis, outcome of patients receiving emergency TTE

Patient number	Coexisting diseases	Formal echo/hemodynamic	New finding	Modified anesthetic management/diagnosis and outcome
1	DCM	Reduced EF	Reduced LV contractility Global WMA	Invasive blood pressure monitoring inotropic agents, furosemide nicardipine
2	DCM	Reduced EF	Reduced LV contractility Global WMA Dense in B lines	Invasive blood pressure monitoring inotropic agents, furosemide
3	CAD Post-CABG	RWMA	RWMA, reserved EF	Inotropic agents, nitroglycerin
4	Nil	Nil	Displacement of cancer embolus to second portal of the liver in IVC	Surgery cancelled
5	Malignant tumor	Nil	Massive pleural effusion	Thoracentesis, surgery cancelled
6	HOCM	Dynamic LVOT obstruction	Peak PG of LVOT ≤ 25 mmHg under Valsalva maneuver	Invasive blood pressure monitoring surgery completed uneventfully
7	RHD, MS, CHF	Severe MS Low EF	AHF, tachy-AF	Invasive blood pressure monitoring died in 6 h postsurgery in ICU
8	Constrictive pericarditis	Pericardium calcification	Massive peritoneal effusion	Invasive blood pressure monitoring Restrictive fluid management
9	CAD, CHF	Moderately reduced EF	Reduced LV contractility Global WMA	Surgery cancelled
10	HPN, COPD, DVT	Cardiac arrest	Increased IVC collapsibility, normal VTI	ROSC, vasoplegia Surgery cancelled
11	HPN, COPD, asthma AVB-I cRBBB	Circulatory collapse	Increased IVC collapsibility, normal VTI	Rescued, vasoplegia Surgery finished
12	Parkinson's disease	Cardiac arrest	Increased IVC collapsibility, reduced VTI	ROSC, hypovolemic Surgery finished
13	HPN, cerebral infarction	Circulatory collapse	Inferior wall RWMA Reduced VTI	Rescued, hypovolemic Myocardial ischemia, surgery cancelled
14	HPN, anemia, cerebral infarction	Circulatory collapse	Increased IVC collapsibility, normal VTI	Rescued, anaphylaxis Surgery cancelled
15	CHF, CAD, HPN, CRF, post-PCI stent implantation	Low saturation AHF	Global WMA Dense in B lines	Myocardial ischemia Surgery completed Transfer to ICU
16	Stroke, chronic AF	Low saturation Tachy AF	MS, AI, dense B lines	Moderate MS Lung edema Hemodynamic stability
17	Post-MVR, CAD CHF	Severe hypotension	Suppressed LV contractility	Myocardial ischemia Hemodynamic stability Surgical completed

TTE: Transthoracic echocardiography; VTI: Velocity time interval; ICU: Intensive Care Unit; DCM: Dilated cardiomyopathy; EF: Ejection fraction; LV: Left ventricle; CAD: Coronary arterial disease; CABG: Coronary artery bypass grafting; G/RWMA: Global/regional wall motion abnormality; IVC: Inferior vena cava; HOCM: Hypertrophic obstructive cardiomyopathy; LVOT: Left ventricle outflow tract; Peak PG: Peak pressure gradient; RHD: Rheumatic heart disease; CHF: Chronic heart failure; MS: Mitral stenosis; AHF: Acute heart failure; HPN: Hypertension; COPD: Chronic obstructive pulmonary disease; DVT: Deep venous thrombosis; ROSC: Return of spontaneous circulation; CA: Cardiac arrest; cRBBB: Complete right bundle branch block; AVB-I: First degree atrioventricular block; PCI: Percutaneous coronary intervention; AI: Aortic insufficiency; Tachy-AF: Atrial fibrillation with tachycardia; MVR: Mitral valve replacement.