“Rescue TEE” for Noncardiac Surgery

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Learner Outcomes

- Describe the role of TEE as an advanced cardiac monitor for noncardiac surgery
- Define “rescue echocardiography” as it applies to severe perioperative hemodynamic instability
- Identify common TEE findings in patients with severe hemodynamic instability
- Describe the impact of rescue TEE on anesthetic management
Car vs Tree and Rescue TEE

- 20 year-old female taken to CT scanner after motor vehicle accident
- Cardiac arrest ensued with pulseless electrical activity and she was taken to the operating room
- Rescue TEE was performed, demonstrating cardiac tamponade
- Pericardial space was drained and the patient subsequently recovered

Rescue Transesophageal Echocardiography

- Urgent and emergent use of transesophageal echocardiography (TEE)
- Allows effective diagnosis of the causes of hemodynamic instability during cardiac and noncardiac surgical procedures
- Intraoperative causes can be categorized as
  - Hypovolemic
  - Distributive
  - Cardiogenic
  - Obstructive

Recommended Uses of TEE

- **Cardiac Surgery**
  - All open heart procedures (e.g., heart valves) and aorta procedures
  - CABG for new or unsuspected pathology or to assess results of surgical intervention
  - Transcatheter intracardiac procedures (e.g., TAVR)

- **Noncardiac Surgery**
  - Nature of the planned surgery or the patient’s known or suspected cardiovascular pathology might result in severe hemodynamic, pulmonary, or neurologic compromise
  - When unexplained life-threatening circulatory instability persists despite corrective therapy

- **Critical Care**
  - When diagnostic information that is expected to alter management cannot be obtained by TTE or other modalities in a timely manner

General Indications for Rescue TEE

- Refractory hypotension
- Hypoxia/PFO/ASD
- ECG changes/arrhythmias
- Shock/cardiac arrest
- Myocardial ischemia
- Tamponade/dissection
Key Rescue TEE Windows

Transgastric Midpapillary

Midesophageal Four Chamber

Midesophageal Long Axis

Anterior

Septum

Inferior

Lateral

Anterolateral

LA

LV

RA

RV

Ao

LA

RV

LV
Instability due to Hypovolemia

- Hypotension and low cardiac output is due to reduced intravascular volume
- Up to 42% of all patients requiring rescue TEE had findings consistent with hypovolemia
- Hypovolemia manifests as a small LV cavity size associated with normal or hyperdynamic global LV systolic function
Instability due to Vasodilation

- Hemodynamic instability due to severe peripheral vasodilation with reduced systemic vascular resistance
- Findings consistent with low SVR states were present in 4.4 percent of rescue echo patients
- Low SVR manifests as a very small left ventricular (LV) cavity at end-systole, but with normal end-diastolic values
Instability due to Obstructive Shock

- Hemodynamic instability with inflow/outflow obstruction is due to reduced cardiac output caused by an extracardiac cause of cardiac pump failure.

- Usually associated with physical obstruction of the great vessels or heart.

- Pulmonary embolism and tamponade are the most common forms (nail in the heart least common).
Cardiac Tamponade

- Hemodynamic instability due to cardiac tamponade is present in 7 to 9 percent of patients.
- The incidence is highest in trauma patients, CPR and in pacemaker or defibrillator lead extraction.
- Findings in cardiac tamponade typically include collapse of the right atrium (RA), right ventricle (RV) and possibly left ventricle (LV).
Tamponade and Intervention
Pulmonary Embolism

- Rescue echo diagnoses thromboembolic PE in up to 16 percent of noncardiac surgical patients (usually orthopedic surgery)
- Overall sensitivity of TEE for PE detection is typically 50-80%
- Rescue TEE or transthoracic echocardiography (TTE) has also been used to diagnose air, fat, cement, tumor, or amniotic fluid embolic phenomena
Cardiogenic Shock-LV Failure

- Hemodynamic instability with cardiogenic shock is due to reduced cardiac output (CO)
- Findings consistent with LV failure were present in up to 50 percent of patients during rescue TEE
- Using transgastric LV midpapillary short-axis (TG LV SAX) view, qualitative estimates of LV systolic function and LV ejection fraction (LVEF) can be rapidly obtained
Cardiogenic Shock-RV Failure

- Hemodynamic instability due to moderate or severe RV failure were present in up to 29 percent of patients.
- Causes of RV dysfunction include PE, myocardial ischemia or infarction, pulmonary arterial hypertension, or primary respiratory failure.
- Global RV failure is qualitatively assessed on the ME 4C view, with TR or reduced tricuspid valve annular plane systolic excursion towards the RV apex.
Myocardial Ischemia/Infarction

- Myocardial ischemia was present in up to 27 percent of patients undergoing rescue TEE

- Normal ventricular systolic function includes both endocardial excursion toward the center of the LV cavity and systolic thickening of the LV wall

- Myocardial ischemia is qualitatively assessed by detecting RWMAs on the TEE short and long-axis views of the LV
Severe AS is suggested by heavily calcified or poorly mobile aortic valve leaflets.

Continuous-wave Doppler measurement of the transvalvular gradient can usually be obtained to confirm the diagnosis (>40 mmHg suggests severe AS).

LVH is often present and hemodynamic management dictated by this finding.
Aortic Insufficiency

- Color flow Doppler is used to measure the largest jet width in the LVOT.
- Jet width is expressed as a percentage of the width of the LVOT.
- Mild regurgitation is a jet width <25 percent of the LVOT (severe ≥65 percent of the LVOT).
- Causes of acute aortic regurgitation include acute aortic dissection involving the aortic root or endocarditis.
Mitral Regurgitation

- Causes of acute severe MR include chordal/papillary rupture, or as a consequence of myocardial ischemia, decompensated heart failure or SAM.

- MR is qualitatively estimated in the ME 4C or ME LAX view using color-flow Doppler to assess regurgitant jet size.

- Ongoing assessment may provide an index of the success of interventions.
Mitral Stenosis

- Severe mitral stenosis (MS) is best identified using the ME 4C view
  - Mitral valve thickening is observed with reduced leaflet opening
  - High-velocity LV inflow on color-flow Doppler imaging

- Severe MS may be seen on rescue TEE in patients with evidence of severe RV dysfunction, and is often associated with pulmonary hypertension
Dynamic LVOT obstruction and/or mitral valve SAM have been noted in approximately 4 percent of patients undergoing intraoperative rescue TEE.

LVOT obstruction and the severity of MR are influenced by cardiac loading conditions and inotropic state.

Tachycardia and low SVR worsen the SAM and decrease forward flow.
Aortic Dissection

- Rescue TEE findings consistent with aortic injury may be found.
- Aortic dissection or other injury is most commonly diagnosed by TEE in certain patients presenting to the ER.
- Only limited visualization of the distal ascending aorta and proximal aortic arch is possible with TEE examination (TTE suprasternal view better).
Atrial/Ventricular Septal Defect

- Rescue TEE used for any cardiopulmonary instability, including hypoxemia
- While uncommon, ASD/VSD may be found in the setting of hypoxemia especially with recent MI
- Color flow mapping demonstrates blood flow direction and velocity
Most Common Findings in Rescue TEE (Jasdaviuus)

- Systematic review of echo use in high risk (n=568) or hemodynamically unstable (n=400) patients

- The most frequent diagnoses were valvulopathy, low LVEF, hypovolemia, PE, wall motion abnormalities, and RV failure

- Studies included employed comprehensive echo exams performed by those with advanced training

<table>
<thead>
<tr>
<th>Finding</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low EF</td>
<td>20.5%</td>
</tr>
<tr>
<td>RV Dysfunction</td>
<td>13.1%</td>
</tr>
<tr>
<td>Hypovolemia</td>
<td>32.2%</td>
</tr>
<tr>
<td>New Wall Motion Abnormality</td>
<td>10.2%</td>
</tr>
<tr>
<td>Pulmonary Embolism</td>
<td>5.8%</td>
</tr>
<tr>
<td>All other diagnoses</td>
<td>17.7%</td>
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</tbody>
</table>

Most Common Findings in Rescue TEE (Shilcutt)

- TEE exam (8 of 11 PTE views)
- TTE exam (4 FATE and 3 other views)
- Impact was significant
  - Drug treatment change in 21 patients
  - Fluid or ventilator change in 10 patients

<table>
<thead>
<tr>
<th>Finding</th>
<th>n/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV Dysfunction-Systolic</td>
<td>14 (45%)</td>
</tr>
<tr>
<td>LV Dysfunction-Diastolic</td>
<td>10 (32%)</td>
</tr>
<tr>
<td>RV Dysfunction</td>
<td>9 (29%)</td>
</tr>
<tr>
<td>Hypovolemia</td>
<td>5 (16%)</td>
</tr>
<tr>
<td>New Wall Motion Abnormality</td>
<td>4 (13%)</td>
</tr>
<tr>
<td>Cardiac Tamponade</td>
<td>1 (3%)</td>
</tr>
<tr>
<td>Pulmonary Embolism</td>
<td>5 (16%)</td>
</tr>
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Interventions Based on Findings (Markin)

- Review of 364 rescue echo studies at Utah
- Rescue TEE consult obtained, exam by established perioperative TEE team
- Emphasis was on diagnoses and management impact
- 62% of TEE exams resulted in management changes
- 41% resulted in volume administration, 17% in inotropes, 12% in vasopressors

## Management Impact of Interventions

### Management Changes as a Result of Rescue Echocardiography Findings

<table>
<thead>
<tr>
<th>Management Changes N = 364</th>
<th>Number of Rescue Echocardiograms Showing Management Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (%)</td>
</tr>
<tr>
<td>All management changes</td>
<td>214 (58.8%)</td>
</tr>
</tbody>
</table>

### Types of management changes:

<table>
<thead>
<tr>
<th>Management Change</th>
<th>Total (%)</th>
<th>Intraoperative (%)</th>
<th>Postoperative (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid administration</td>
<td>113 (31.0%)</td>
<td>83 (41.1%)</td>
<td>30 (18.5%)</td>
</tr>
<tr>
<td>Inotropes</td>
<td>64 (17.6%)</td>
<td>34 (16.8%)</td>
<td>30 (18.5%)</td>
</tr>
<tr>
<td>Vasopressors</td>
<td>40 (11.0%)</td>
<td>25 (12.4%)</td>
<td>15 (9.3%)</td>
</tr>
<tr>
<td>Inhaled vasodilators</td>
<td>8 (2.2%)</td>
<td>3 (1.5%)</td>
<td>5 (3.1%)</td>
</tr>
<tr>
<td>Diuretics</td>
<td>5 (1.4%)</td>
<td>1 (0.5%)</td>
<td>4 (2.5%)</td>
</tr>
<tr>
<td>Surgical changes</td>
<td>27 (7.4%)</td>
<td>9 (4.5%)</td>
<td>17 (10.5%)</td>
</tr>
<tr>
<td>Other medical changes</td>
<td>18 (4.9%)</td>
<td>11 (5.4%)</td>
<td>7 (4.3%)</td>
</tr>
</tbody>
</table>

Markin et al J Cardiothorac Vasc Anesth. 2015;29:82-8
## Rescue TEE-Diagnostic Targets

<table>
<thead>
<tr>
<th>Clinical Interest</th>
<th>Evaluation</th>
</tr>
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<tbody>
<tr>
<td>LV systolic function and dimensions</td>
<td>LV dysfunction, dilation (Eyeball EF)</td>
</tr>
<tr>
<td>RV systolic function</td>
<td>RV dysfunction (TAPSE, free wall motion)</td>
</tr>
<tr>
<td>Volume status</td>
<td>Chamber size (Kissing paps, systolic size)</td>
</tr>
<tr>
<td>Pericardial effusion</td>
<td>Presence of pericardial effusion, chamber compression</td>
</tr>
<tr>
<td>Gross signs of chronic heart disease</td>
<td>Atrial/ventricular hypertrophy, LV to RV size ratio</td>
</tr>
<tr>
<td>Gross valvular abnormalities</td>
<td>Orifice, leaflet coaptation, Color Flow Mapping/Doppler</td>
</tr>
<tr>
<td>Intracardiac Masses</td>
<td>Vegetations, intracardiac masses or thrombi</td>
</tr>
<tr>
<td>Wall motion abnormality</td>
<td>Thickening, hypokinesis/akinesis</td>
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- Blood/fluid loss?
- Vascular compression?
- Too much anesthesia?
- Pulmonary embolism?
- Pericardial Tamponade?
- LV Outflow tract obstruction?
- Myocardial dysfunction/ischemia?
- Something else?
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- TRALI?
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Efficacy of Rescue TEE

- Useful in hemodynamic instability with the goal of preventing progression to cardiopulmonary arrest
- Particularly useful if the immediate cause of instability is uncertain or to ensure appropriate treatment of persistent instability
- Rescue TEE can provide a working diagnosis that led to additional therapies in >80 percent of patients

Implementation of Rescue TEE Service

- Rescue TEE teams may include anesthesia or cardiology, as well as other personnel (e.g., a sonographer or anesthesia technician).
- Visual cognitive aids that focus on key views may be used to facilitate rapid diagnosis in emergent situations.
- Checklists may be employed to facilitate immediate appropriate management once a diagnosis is made by the rescue TEE team.
Focused Assessed Transthoracic Exam (FATE)

- Standard ultrasound/TTE positions
- Image quality has learning curve
- Basic anatomical and functional assessment
  - Ventricular function
  - Valvular function
  - Volume status
  - Pulmonary function


http://www.pie.med.utoronto.ca/TTE/TTE_content/focus.html
FATE Exam PS SAX LV Function
FATE Exam PS LAX LV Function
Summary/Recommendations

- Rescue Echo has broad utility in the care of perioperative patients undergoing anesthesia
  - Differential diagnosis of clinical findings
  - Rescue from cardiopulmonary instability
  - Rapid diagnosis, immediate assessment including response to treatment
  - Avoid unnecessary procedures
- TEE is widely accepted and utilized during major surgery in high risk patients for cardiac and noncardiac surgery
  - Monitoring
  - Diagnostics
- TTE is useful before, during and after anesthesia in a wide range of patients and clinical settings
References

- Shillcutt SK, Markin MW, Montzingo CR and Brakke TR. Use of rapid “rescue” perioperative echocardiography to improve outcomes after hemodynamic instability in noncardiac surgical patients. JCTVA, 2012; 26:362-370