The surgeon’s perspective on PE

Cold steel to heal?

Nima Hatam
Disclosure

Speaker name:
Nima Hatam

I have the following potential conflicts of interest to report:

- [x] Consulting
- [ ] Employment in industry
- [ ] Stockholder of a healthcare company
- [ ] Owner of a healthcare company
- [ ] Other(s)

- [ ] I do not have any potential conflict of interest
“Imagine a scenario in which an operation is declared a failure before the skin incision is made, regardless of the results.”
Why?
“…cross clamping of the artery should not exceed ¾ minute…”

“...arterial suture being the most complicated part of the operation because the heart has started to pulsate violently…”

100 % mortality
Ein durch die Trendelenburgsche Operation geheilter Fall von Embolie der Art. pulmonalis.

Von
M. Kirschner.

(Aus der Chirurgischen Universitäts-Klinik Königsberg i. Pr. —
Direktor: Prof. Dr. M. Kirschner.)

Mit 1 Textabbildung.

Das Krankheitsbild der Lungenembolie gliedert sich zwanglos in 2 Gruppen:

Bei der einen Gruppe bleiben kleine Emboli in den feineren Verzweigungen der Art. pulmonalis stecken; die Erkrankung tritt, abgesehen von dem gelegentlichen Einsetzen mehr oder weniger heftiger Brustschmerzen, in der Regel ohne stürmische Erscheinungen auf, und erst nach einiger Zeit machen sich die Zeichen eines Lungeninfarktes, Infiltration eines umschriebenen Lungenbezirkes, bronchopneumonische und pleuritische Herde und blutiges Sputum bemerkbar.

Bei der anderen Gruppe verstopfen die Emboli den Hauptstamm oder die größeren Äste der Art. pulmonalis; die Träger erkranken in Form einer plötzlichen, lebensbedrohenden Katastrophe mit hochgradigster Todesangst, Atemnot und Herzschwäche; sie gehen fast ausnahmslos nach einigen Minuten oder Stunden an Sauerstoffmangel oder Erlahmung der Herzkraft qualvoll zugrunde.

Diese große oder massige Form der Embolie der Lungenembolie, von der im folgenden im wesentlichen allein die Rede sein soll, ist eine der furchtbarsten Gefahren, die drohend über jedem Krankenlager schwebt. Sie ereignet sich mit Vorliebe nach chirurgischen Eingriffen. Neben dem Auftreten einer schweren Infektion nach einer an sich aseptischen Operation erscheint kaum etwas anderes geeignet, den Glauben an die chirurgische Kunst stärker zu erschüttern als ein derartiges unglückseliges Erlebnis. Nur der, der eine operative Tätig-

0 % mortality
Classic Indication SPE

*only* hemodynamically unstable pts. with systolic RR < 90 mmHg despite administration of 2 vasopressors

→ never evidence based/challenged
→ heterogeneous procedures, mostly CPB
→ most pts. in cardiogenic shock with or w/o MOF
→ mortality rates up to 50 %!
Surgical Embolectomy for Acute Pulmonary Embolism: Systematic Review and Comprehensive Meta-Analyses

Bajaj Kalra, MBChB,* Navkarunbir S. Bajaj, MD, MPH,† Pankaj Arora, MD, Garima Arora, MD, William A. Cronland, MD, David C. McGuffin, MD, and Mustafa I. Ahmed, MD

Departments of Medicine and Division of Cardiothoracic Surgery, University of Alabama at Birmingham, Birmingham, Alabama; Cardiology, Brigham and Women’s Hospital and Harvard Medical School, Boston, Massachusetts; Division of Cardiology, University of Alabama at Birmingham, Birmingham, Alabama; and Division of Cardiothoracic Surgery, University of Alabama at Birmingham, Birmingham, Alabama

Surgical pulmonary embolism (SPE) is a viable treatment approach for subsets of patients with acute pulmonary embolism. However, outcomes data are limited. We sought to characterize mortality and safety outcomes for this population. Studies reporting inhospital mortality for patients undergoing SPE for acute pulmonary embolism were included. In 56 eligible studies, we found 1,579 patients who underwent 1,590 SPE operations. The pooled inhospital all-cause mortality was 20.9% (95% confidence interval 12.2% to 30.6%). Surgical site complications occurred in 7.4% of operations (95% confidence interval 4.9% to 10.8%). More investigation is required to define the patient population that would benefit the most from SPE.

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- database research from 1945 to 2015
- 56 studies including 1,579 pts. undergoing 1,590 SPEs
- mean & median age 42 to 65 years
Table 2. Mortality Outcomes of Patients Undergoing Surgical Pulmonary Embolectomy for Pulmonary Embolism

Supplemental Table 5: Time Trend Subgroup Analysis

<table>
<thead>
<tr>
<th>Publication Year of the Studies</th>
<th>N studies</th>
<th>Point Estimate of In-Hospital Mortality (Confidence Intervals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to the year 2000</td>
<td>29</td>
<td>32.1% (26.9-37.7%)</td>
</tr>
<tr>
<td>After the year 2000</td>
<td>27</td>
<td>19.0% (14.6-24.3%)</td>
</tr>
</tbody>
</table>

*p value <0.001
Legend: N=number.
Surgical Embolectomy for Acute Pulmonary Embolism: Systematic Review and Comprehensive Meta-Analyses

Rajat Kalra, MBChB,* Navkaranbir S. Bajaj, MD, MPH,* Pankaj Arora, MD, Garima Arora, MD, William A. Crosland, MD, David C. McGiffin, MD, and Mustafa I. Ahmed, MD

Fig 2. Forest plot depicting inhospital mortality rates (per 100 patients) undergoing surgical pulmonary embolectomy for acute pulmonary embolism. Each black diamond is the point estimate, the line represents the 95% confidence interval (CI). The gray box represents the weight of the studies. The hollow red diamond and dashed red line represent the random effects generated overall estimate.
Results SPE

- one third w/CA
- substantial improvement over the decades
- post-millennial good acute and LT-outcomes for SPE
- mortality reported 3.6 to 23 %
- low major bleeding complications
- extensive /secure thrombus extraction
But
Risks SPE

RV dysfunction

Bleeding

source: contilia.de
RV dysfunction

Abnormal right heart filling after cardiac surgery: time course and mechanisms

Beige Werner, Faustos I. Papi, Rajeev Harisinghani, Frederick G. Lee, Charles, Joseph P. Pinsky, Richard L. Popp

Abstract

Objective: To study the time course and underlying mechanisms of right heart filling after cardiac surgery.
Design: A prospective observational study of adult patients undergoing cardiac surgery.
Setting: Echocardiography laboratory of the Stanford University Medical Center.

Patients: Twenty-six patients (mean age 61.8 years) undergoing cardiac surgery were studied before and after two days, one week, two weeks, and six months after cardiac surgery.

Main outcome measures: Flow in the hepatic veins and superior vena cava, tricuspid and mitral annulus motion, sign of tricuspid regurgitation, and right ventricular size assessed by echocardiography.

Results: Right heart filling, expressed as the ratio of systolic to diastolic forward flow Doppler velocity integrals in the superior vena cava and by tricuspid annulus motion, decreased in parallel from before surgery baseline values of 5.9 (95% I.D. 3.6 and 9.1) (± 2.4) mm and 6.1 (95% I.D. 3.1 and 8.1) (± 3.1) mm two days after operation. A gradual increase towards baseline values was noted after six months, to 6.4 (95% I.D. 3.1) and 6.1 (95% I.D. 3.1) mm respectively, however, these values were still significantly less than those before operation. Similar changes were seen in the hepatic venous flow pattern. The decrease in total tricuspid annulus motion was most pronounced in its anterior segment and the annular component of the tricuspid annulus motion showed similar changes.

Conclusions: The pronounced decrease in tricuspid annulus motion during the early postoperative period suggests right atrial and right ventricular dysfunction as mechanisms responsible for the early changes seen. The progressive return to a normal venous filling pattern and the partial recovery of annulus motion six months after operation further supports the influence of the above mechanisms, as well as their resolution with time. The persisting flow abnormalities and compromised motion of the free portion of the tricuspid annulus, however, suggest long-term underlying of the right heart wall.

Conclusion

This study shows that the reduction in RV long-axis myocardial velocities occurs at the time of pericardial opening during CABG surgery.

The reason for this long-lasting selective reduction remains unclear, but the intense and consistent temporal association with pericardial opening (which removes external support to the RV from the pericardium) suggests that the pericardium contributes much more to the preservation of peak RV myocardial annular velocities than previously supposed. Virtually, all of the RV long-axis reduction seen during coronary surgery occurs at the time of pericardial incision.
Surgical Embolectomy for Acute Pulmonary Embolism: Systematic Review and Comprehensive Meta-Analyses

Rajat Kalra, MChcH,1 Navkarandeo S. Rajal, MD, MPH,2 Pankaj Arora, MD,3 Gartima Arora, MD, William A. Croslan, MD, David T. McQuaid, MD, and Mustafa E. Ahmed, MD

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Table 4. Operative Characteristics and Outcomes for All Patients and for Massive and Submassive Pulmonary Embolism Subgroups

<table>
<thead>
<tr>
<th>Patient Outcomes</th>
<th>All (n=115)</th>
<th>Massive (n=49)</th>
<th>Submassive (n=66)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perfusion time, min</td>
<td>60 (38-90)</td>
<td>69 (47-96)</td>
<td>56 (36-76)</td>
<td>0.089</td>
</tr>
<tr>
<td>Cross-clamp time, min</td>
<td>44 (13-75)</td>
<td>49 (29-120)</td>
<td>46 (16-67)</td>
<td>0.041</td>
</tr>
<tr>
<td>RV failure</td>
<td>5.3 (6)</td>
<td>8.2 (4)</td>
<td>3.6 (1.2)</td>
<td>0.031</td>
</tr>
<tr>
<td>RVAD placed</td>
<td>1.8 (2)</td>
<td>2.0 (1)</td>
<td>1.8 (1)</td>
<td>1.000</td>
</tr>
<tr>
<td>Postoperative complications</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DSIVI</td>
<td>2.6 (3)</td>
<td>2.0 (1)</td>
<td>1.8 (1)</td>
<td>1.000</td>
</tr>
<tr>
<td>Permanent stroke</td>
<td>2.6 (3)</td>
<td>4.0 (2)</td>
<td>1.8 (1)</td>
<td>0.598</td>
</tr>
<tr>
<td>New onset RF</td>
<td>6.1 (7)</td>
<td>6.1 (3)</td>
<td>7.3 (4)</td>
<td>1.000</td>
</tr>
<tr>
<td>Coagulopathy</td>
<td>11.4 (13)</td>
<td>10.2 (5)</td>
<td>12.7 (7)</td>
<td>0.765</td>
</tr>
<tr>
<td>Tamponade</td>
<td>3.4 (4)</td>
<td>2.0 (1)</td>
<td>3.5 (2)</td>
<td>0.620</td>
</tr>
<tr>
<td>Nephropathy</td>
<td>8.3 (4)</td>
<td>8.3 (4)</td>
<td>7.3 (4)</td>
<td>1.000</td>
</tr>
<tr>
<td>Recurrent PE</td>
<td>7.0 (8)</td>
<td>6.1 (3)</td>
<td>7.1 (4)</td>
<td>1.000</td>
</tr>
<tr>
<td>Hospital outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilation time, hours</td>
<td>8.5 (5.2-26.5)</td>
<td>12.2 (6.4-39.9)</td>
<td>7.4 (3.3-14.9)</td>
<td>0.130</td>
</tr>
<tr>
<td>Ventilation &gt;24 hours</td>
<td>20.2 (23)</td>
<td>30.6 (15)</td>
<td>12.7 (7)</td>
<td>0.032</td>
</tr>
<tr>
<td>ICU stay, hours</td>
<td>64 (39-105)</td>
<td>67 (40-129)</td>
<td>58 (24-93)</td>
<td>0.310</td>
</tr>
<tr>
<td>Postoperative LOS, days</td>
<td>9 (7-14)</td>
<td>10 (8-16)</td>
<td>8 (7-14)</td>
<td>0.157</td>
</tr>
<tr>
<td>Operative mortality</td>
<td>6.9 (8)</td>
<td>10.2 (8)</td>
<td>3.6 (2)</td>
<td>0.247</td>
</tr>
<tr>
<td>One-year mortality</td>
<td>20.0 (23)</td>
<td>30.6 (15)</td>
<td>12.5 (7)</td>
<td>0.031</td>
</tr>
</tbody>
</table>

Values are median (interquartile range) or percent (n).

DSIVI = deep sternal wound infection; RVAD = right ventricular assist device.

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Bleeding

Massive pulmonary embolism: surgical embolectomy versus thrombolytic therapy—should surgical indications be revisited?

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Department of Cardiothoracic Surgery, University of Bern, Bern, Switzerland

Abstract

OBJECTIVES: The treatment of massive pulmonary embolism (PE) is a matter of debate. We present two institutional experiences of patients suffering from massive PE with the aim of comparing the early results, the outcome and quality of life (QOL) related to surgical pulmonary embolectomy (SE) and to thrombolysis (TL). A subset of patients (PS) with failed thrombolysis (TL) were treated with surgical embolectomy (SE) in our institution.

METHODS: Data were collected between 2001 and 2007 on all patients suffering from PE who were treated in our institution. All surgical procedures were performed under deep anesthesia. The mean age of the patients was 56 years (range: 20-87). The early mortality rate was 13.5% and was even lower in the SE group (6.6%). The follow-up period was at least 1 year for all patients. The QOL of both groups was compared with the SF-36 questionnaire.

RESULTS: Failures of TL were considered as a subset of PS. The mean age of the patients was 56 years (range: 20-87). The early mortality rate was 13.5% and was even lower in the SE group (6.6%). The follow-up period was at least 1 year for all patients. The QOL of both groups was compared with the SF-36 questionnaire.

CONCLUSIONS: TL is an excellent treatment option in massive PE with comparable early mortality rates. Further studies are required to confirm these results.

Keywords: Pulmonary embolism • Thrombolysis • Surgery

Table 2: Early and late outcomes

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Surgery</th>
<th>Lyse</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Mortality</td>
<td>3.6%</td>
<td>13.5%</td>
<td>0.25</td>
</tr>
<tr>
<td>Bleeding</td>
<td>3.6%</td>
<td>26.5%</td>
<td>0.02</td>
</tr>
<tr>
<td>Cerebral bleeding</td>
<td>3.6%</td>
<td>4.4%</td>
<td></td>
</tr>
<tr>
<td>Neurological event</td>
<td>17.9%</td>
<td>20.4%</td>
<td>1</td>
</tr>
<tr>
<td>At follow-up Mortality</td>
<td>17.9%</td>
<td>23.1%</td>
<td>0.6</td>
</tr>
<tr>
<td>Re-PE</td>
<td>0%</td>
<td>0%</td>
<td>1</td>
</tr>
</tbody>
</table>

Aymard T 2013 Eur J Cardiothorac Surg 43:1, 90-4
Surgical embolectomy compared to thrombolysis in acute pulmonary embolism: morbidity and mortality

Downsides SPE

• persistent RV dysfunction
• invasiveness
• postop respiratory complications
• procedural Duration
• hospital stay
• (bleeding)
• (thrombus age)

lack of evidence
PE—what now?

- fast RV recovery
- minimal invasive procedure (closed chest)
- quick access
- low bleeding complications
ULTIMA\textsuperscript{1} and SEATTLE\textsuperscript{2} showed USAT superior to anticoagulation alone

- quick recovery of RV dysfunction
- low major bleeding complications

\textsuperscript{1}Kucher N 2014 Circulation;129:479-486
\textsuperscript{2}Piazza 2015 JACC Cardiovasc Interv 8:10, 1382-92
Low dose USAT

Optimum Duration and Dose of r-tPA with the Acoustic Pulse Thrombolysis Procedure for Submassive Pulmonary Embolism: OPTALYSE PE

Victor Tapson1, Gregory Piazza2, Keith Sterling1, Kenneth Quinl1, Ping-Yu Liu1, Samuel Z. Goldhaber2

Patients
Acute PE with RV/LV ratio >0.9
(n = 101; 17 centres)

Objectives
Evaluate the optimal duration and dose of Acoustic Pulse Thrombolysis™ (APT) treatment using r-tPA administered via the EKOS™ system:
- Efficacy – Change in RV/LV ratio on CTA at 48hrs
- Safety – As measured by major bleeding within 72hrs

Cohort 1
26 Patients
2hrs EKOS™
4/8mg r-tPA*

Cohort 2
26 Patients
4hrs EKOS™
4/8mg r-tPA*

Cohort 3
27 Patients
6hrs EKOS™
6/12mg r-tPA*

Cohort 4
4/8mg r-tPA*

* Total mg r-tPA: one/two catheters
Case series

- between June and October 2017
- 3 pts (2 male (60 & 61 year old), 1 female 16 year old) with symptomatic PE (mean PESI: 169) early after surgery
- 2 EKOS® 12 cm devices in each respective PA for 6 hours
- 1 mg/h/catheter rt-PA \(\rightarrow\) \(\Sigma:\) 12 mg
- Echo (4/6/12 h) and CTPA within 24 hours
## Case series

### Relevant Parameters and p-values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Baseline</th>
<th>48 h.</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>125 ± 17</td>
<td>78 ± 11</td>
<td>0.103</td>
</tr>
<tr>
<td>TAPSE {mm}</td>
<td>14.5 ± 3.8</td>
<td>21.5 ± 4.0</td>
<td>0.146</td>
</tr>
<tr>
<td>TASV {cm/s}</td>
<td>7.5 ± 2.1</td>
<td>15.8 ± 2.3</td>
<td>0.071</td>
</tr>
<tr>
<td>RV/LV ratio</td>
<td>1.3 ± 0.2</td>
<td>0.7 ± 0.08</td>
<td><strong>0.043</strong></td>
</tr>
<tr>
<td>RV ST %</td>
<td>-13.8 ± 3.5</td>
<td>-20.6 ± 2.9</td>
<td>0.117</td>
</tr>
<tr>
<td>RV STR {s⁻¹}</td>
<td>-1.12 ± 0.07</td>
<td>-1.37 ± 0.05</td>
<td><strong>0.011</strong></td>
</tr>
<tr>
<td>SPAP {mmHg}</td>
<td>47.3 ± 10.8</td>
<td>31.7 ± 11.5</td>
<td>0.060</td>
</tr>
<tr>
<td>MPAP {mmHg}</td>
<td>33.4 ± 6.1</td>
<td>21.7 ± 3.2</td>
<td><strong>0.021</strong></td>
</tr>
<tr>
<td>O2 sat. [%]</td>
<td>83.6 ± 4.1</td>
<td>99.3 ± 1.1</td>
<td><strong>0.012</strong></td>
</tr>
</tbody>
</table>

No major bleeding
Conclusion

• current **SPE** shows **excellent results**
  – **but** RV-dysfunction, venous return
  – (bleeding, thrombus age)

• **USAT**
  – fast RV recovery
  – closed chest
  – quick access
  – low bleeding complications

• proper studies required
Thank you for your attention

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