Splenic Devascularization can Replace Splenectomy During LDLT

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Indication of Splenectomy (SPX) in LDLT

- Pancytopenia related to Splenomegaly
  - Leukocyte < 3.5K/mm³
  - Platelet < 70K/mm³
- Small-for-size graft (GRWR < 0.8~1.0%)
- HCV related ESLD for pegylated IFN + ribavirin therapy
- Splenic artery aneurysm
Complication of Splenectomy (SPX)

- Splenic vein &/or Portal vein thrombosis
- Postoperative bleeding
- Infectious complications
- Pancreatic fistula
Historical Case (PV Thrombosis)

- Female / 56 years
- HBV related ESLD

- 2006.6.1
  LDLT using modified RL

- 2013.7.8
  Splenectomy
  Due to thrombocytopenia related to severe splenomegaly

Normal liver function
Tbil 1.1mg/dL, PT 75.2%(INR 1.14)
Historical Case (PV Thrombosis)

Before Splenectomy

Splenomegaly & Thrombocytopenia

Post-splenectomy 5 Days

Acute Thrombosis at PV & SV
Historical Case (**PV Thrombosis**)

Thrombectomy & PV stenting (2013.7.13)

- Initial intra-OP Portogram
- Final IOP after PV stenting

Current CT (2017.7.15)
Historical Case (Infection)

• Male / 51 years, 168cm / 69.8kg

• HBV-Fulminant hepatic failure

• MELD 33 points
  • T. Bil 37.4mg/dL, Cr 0.8mg/dL, PT 19.9% (INR 3.03)

• LDLT using modified RL (2007.10.24)
  • GRWR 1.12% (700g)
  • Splenectomy accidentally due to splenic tearing
Historical Case (Infection)

Post-LT 3 Days

Chest PA on Post-LT 3, 4, 5 Days
Historical Case (Infection)

PT(%) Trend

Results

LDLT (07.10.24)

AST (SGOT) Trend

POD 4 Day (07.10.28)

POD 5 Day (07.10.29)

Expired (07.10.29)
How About SPA Embolization?

### PV Thrombosis

**Pre-LDLT CT**

**Management**

- Male / 42 years
- HBV-ESLD, MELD 12 points
- Varix bleeding & HCC
- **MRL LDLT (2005.9.29)**
  - GRWR 0.86%
  - PV Thrombectomy
- **SPA ligation was done.**
  - Low GRWR
  - Splenomegaly related pancytopenia
How About Splenic Artery Embolization (SPA-E)?

PV Thrombosis

Before SPA-E CT

Varix bleeding & Pancytopenia
WBC 1.1×10³, Plt 30×10³/mm³

SPA-E (2006.9.18)

Developed collateral arteries
From RGEPi. A, LGA, SMA
How About SPA Embolization?

PV Thrombosis

SPA-E Day 7

Managements

- Retransplantation using DDLT (2012.1.26)
- Currently alive
How About SPA Embolization?

Infection

Clinical History

- Female / 54
- AIH, MELD 31 points
- Acute-on-Chronic liver failure
  - HEP grade 3, Ventilator+
  - HRS+ & CRRT+, Inotropes +
- Urgent MRL LDLT (2008.7.6)
  - GRWR 1.1%
  - Splenorenal shunt ligation (+)
  - SPA ligation (-) for SPAA
- POD 7 day
  - Acute rejection ➔ Pulse Tx.
- POD 9 days
  - Acute bleeding from colon

Post-LDLT Day 9

- Bleeding from colon hepatic flexure
- r/o hypovolemic hepatic ischemia
How About SPA Embolization?

Infection

SPA-Embolization

Post-LDLT Day 10
No bleeding from colon

Chest PA & Simple ABD

SPA-E Day 0 to Day 3
Pulmonary edema, Pneumatosis intestinalis
How About SPA Embolization?

Infection

AST (SGOT) Trend

- LDLT (08.7.6)
- Acute rejection (08.7.13)
- SPA-E (08.7.16)
- GI bleeding (08.7.15)
- Expired (08.7.19)
- Massive PV air Hepatic necrosis
How About SPA Embolization?
Pancreatitis

Clinical History

- Female / 42 years
- HBV-LC, MELD 20 points
  - T.Bil 6.6, Cr 0.42mg/dL, PT 41%(1.78)
- Hepatic encephalophthy
- MRL LDLT (2012.1.5)
  - SPA ligation
    - GRWR 0.81%
    - Multiple SPA aneurysms
- Discharge on post-OP 26 days

Pre-LDLT CT

- Splenomegaly
- Multiple SPAA
How About SPA Embolization?

Pancreatitis

Post-LDLT Day 72

Persistent SPAA

Embolization of SPAA

RG_epi.A, LGA, SMA collaterals
How About SPA Embolization?

Pancreatitis

Post-Embolization 4 Days

- Acute pancreatitis
- Nausea/vomiting, Abd. discomfort

Follow-Up CT

Post-LDLT 5-years
Alternative Managements for SPX

• Splenic artery ligation
  ➢ Possibility of Decreased treatment effect

• Pre- or Post-operative Splenic A. embolization
  ➢ Higher chance of PVT, Sepsis, Pancreatitis

• Splenic De-vascularization
  ➢ Newly devised at AMC
  ➢ Enhancement of SPA ligation effect
  ➢ Decrease the untoward effects of Splenectomy or SPA embolization
Splenic Devascularization (SDV)

1. Division of Gastrosplenic lig.
2. Ligation of Rt. Gastroepiploic A.
3. Ligation of Splenic A
4. Remnant arterial supply via only intrapancreatic collateral from SMA
1. Division of gastrosplenic ligament
2. Ligation of right gastroepiploic artery
3. Ligation of splenic artery
Effective Case of SDV

Intra-OP

Post-OP 7 Days
Methods

• Study periods
  • Splenectomy: April 2013 ~ July 2013
  • Splenic devascularization: August 2013 ~ December 2014
  • Last follow-up time: December 2016

• Patients
  • Adult LDLT patients 123 patients
  • Splenectomy: 62 patients
  • Splenic devascularization: 61 patients

• Comparison
  • Patients characteristics
  • Intraoperative parameters
  • Postoperative outcomes
## Patient Characteristics (I)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total</th>
<th>Splenectomy (N=62)</th>
<th>SDV (N=61)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, male/female</td>
<td>92/31</td>
<td>48/14</td>
<td>44/17</td>
<td>0.54</td>
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<tr>
<td>Age, year</td>
<td>52.6 ± 8.6</td>
<td>51.3 ± 8.7</td>
<td>53.7 ± 8.4</td>
<td>0.16</td>
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<tr>
<td>Primary disease</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>HBV</td>
<td>85 (69.1)</td>
<td>41 (66.1)</td>
<td>44 (72.1)</td>
<td>0.40</td>
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<tr>
<td>Alcoholic</td>
<td>16 (13.0)</td>
<td>11 (17.7)</td>
<td>5 (8.2)</td>
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<tr>
<td>HCV</td>
<td>10 (8.1)</td>
<td>6 (9.7)</td>
<td>4 (6.6)</td>
<td></td>
</tr>
<tr>
<td>Others†</td>
<td>12 (9.8)</td>
<td>4 (6.5)</td>
<td>8 (13.1)</td>
<td></td>
</tr>
<tr>
<td>MELD score</td>
<td>14.4 ± 7.5</td>
<td>15.0 ± 8.3</td>
<td>13.9 ± 6.7</td>
<td>0.43</td>
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<tr>
<td>PreOP CBC, X10³/mm³</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Hemoglobin</td>
<td>10.7 ± 2.1</td>
<td>10.9 ± 2.2</td>
<td>10.6 ± 2.1</td>
<td>0.43</td>
</tr>
<tr>
<td>Platelet</td>
<td>58.8 ± 33.8</td>
<td>62.2 ± 41.2</td>
<td>55.3 ± 23.9</td>
<td>0.26</td>
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<tr>
<td>WBC</td>
<td>3.3 ± 2.2</td>
<td>3.4 ± 2.4</td>
<td>3.1 ± 1.9</td>
<td>0.42</td>
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†: including Cryptogenic, AIH, Wilson’s, SBC, PBC
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<tr>
<td><strong>Variables</strong></td>
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<tr>
<td>Treatment reasons</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Splenomegaly</td>
<td>101 (82.1)</td>
<td>49 (79.0)</td>
<td>52 (85.2)</td>
<td>0.09</td>
</tr>
<tr>
<td>Low GRWR</td>
<td>14 (11.4)</td>
<td>9 (14.5)</td>
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<td></td>
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<tr>
<td>HCV</td>
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<td></td>
</tr>
<tr>
<td>SA aneurysm</td>
<td>1 (0.8)</td>
<td>1 (1.6)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Graft type, right/left/dual</strong></td>
<td>110 / 5 / 8</td>
<td>56 / 2 / 4</td>
<td>54 / 3 / 4</td>
<td>0.83</td>
</tr>
<tr>
<td><strong>Graft volume, gm</strong></td>
<td>741.7 ± 151.8</td>
<td>732.8 ± 153.6</td>
<td>750.8 ± 150.8</td>
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<td><strong>GRWR%</strong></td>
<td>1.12 ± 0.22</td>
<td>1.10 ± 0.03</td>
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<tr>
<td><strong>Treatment time</strong></td>
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<td>Pre-hilar dissection</td>
<td>31 (25.2)</td>
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<td>Post-hilar dissection</td>
<td>92 (74.8)</td>
<td>46 (74.2)</td>
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<tr>
<td><strong>Operation time, minutes</strong></td>
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<td>794.8 ± 118.9</td>
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<td>IntraOP RBC, units</td>
<td>8.3 ± 10.7</td>
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Chronologic Changes of Hemoglobin

![Graph showing changes in hemoglobin levels over time post-splenectomy.]
Chronologic Changes of Platelet Counts

![Graph showing chronicologic changes of platelet counts with time points pre, 1w, 1mon, 3mon, 6mon. The x-axis represents time in months, and the y-axis represents platelet counts in $10^3/mm^3$. The graph compares SDV and Splenectomy groups. The SDV group shows a consistent increase in platelet counts, while the Splenectomy group shows a sudden increase followed by a decrease.]
Chronologic Changes of Leukocyte Counts

![Graph showing changes in leukocyte counts over time post-splenectomy.]
Splenic Volume after SDV

Pre-OP Splenic volume: 1050.8 ml  
(706.2 ± 282.9 ml)

Post-OP 7 Days Splenic volume: 342.0 ml  
(509.5 ± 236.3 ml)
Splenic Volume after SDV

Post-OP 1 month

Splenic volume: 453 ml
(425.5 ± 204.4 ml)

Post-OP 6 month

Splenic volume: 218 ml
(356.5 ± 140.6 ml)
# Postoperative Outcomes (I)

<table>
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<tr>
<th>Variables</th>
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</tr>
</thead>
<tbody>
<tr>
<td>T. Bil on POD 7 (mg/dL)</td>
<td>3.4 ± 3.1</td>
<td>2.9 ± 2.5</td>
<td>3.8 ± 3.5</td>
<td>0.12</td>
</tr>
<tr>
<td>PT on POD 7 (INR)</td>
<td>1.15 ± 0.16</td>
<td>1.1 ± 0.1</td>
<td>1.2 ± 0.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Ascites on POD 7 (ml/day)</td>
<td>585.6 ± 365.3</td>
<td>546.0 ± 368.5</td>
<td>625.9 ± 360.5</td>
<td>0.23</td>
</tr>
<tr>
<td>SFSG syndrome†, number</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Removal of Abd. drain, days</td>
<td>18.9 ± 8.2</td>
<td>18.8 ± 9.3</td>
<td>18.9 ± 6.9</td>
<td>0.91</td>
</tr>
<tr>
<td>Less than T.Bil 2mg/dL, days</td>
<td>14.2 ± 22.1</td>
<td>11.8 ± 23.6</td>
<td>16.7 ± 20.5</td>
<td>0.20</td>
</tr>
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</table>

†: small-for-size graft syndrome, Tbil 10mg/dL and Ascites 1L/d on the postOP day 7
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<tr>
<td><strong>PostOP complication, number ¥</strong></td>
<td>20 (16.3)</td>
<td>15 (24.2)</td>
<td>5 (8.2)</td>
<td>0.026</td>
</tr>
<tr>
<td><strong>Treatment-related Cx., number</strong></td>
<td>8 (6.5)</td>
<td>7 (11.3)</td>
<td>1 (1.6)</td>
<td>0.032</td>
</tr>
<tr>
<td><strong>PostOP thrombosis§</strong></td>
<td>16 (13.0)</td>
<td>14 (22.6)</td>
<td>2 (3.3)</td>
<td>0.002</td>
</tr>
<tr>
<td><strong>Hospital stay, days</strong></td>
<td>31.5 ± 33.9</td>
<td>34.9 ± 43.1</td>
<td>28.1 ± 20.5</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>In-hospital mortality, number</strong></td>
<td>(1.6)</td>
<td>2 (3.2)</td>
<td>-</td>
<td>0.50</td>
</tr>
</tbody>
</table>

¥: Clavien-Dindo classification grade III, IV, V.

Treatment-unrelated complications are mostly bleeding related complication except 2 cases including evisceration, jejunal perforation.

§: distal SVT (n=13), intrahepatic PV branch (n=2), MPV partial thrombus (n=1), Operation (n=0)
## Postoperative Outcomes (II)

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Treatment-unrelated complications are mostly bleeding related complication except 2 cases including evisceration, jejunal perforation.
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### Summary of the Treatment-related Post-OP Complications

<table>
<thead>
<tr>
<th>No.</th>
<th>ME LD</th>
<th>Tx.</th>
<th>Complication</th>
<th>POD</th>
<th>Site</th>
<th>Management</th>
<th>Outcome</th>
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<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>SPX</td>
<td>Bleeding</td>
<td>D1</td>
<td>Splenectomy bed</td>
<td>Laparotomy</td>
<td>Alive</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>SPX</td>
<td>Pancreatic fistula Aneurysm rupture</td>
<td>D1 D43</td>
<td>Pancreas tail Hepatic artery</td>
<td>Pigtail drain Laparotomy &amp; HA ligation</td>
<td>Dead (related sepsis)</td>
</tr>
<tr>
<td>3</td>
<td>19</td>
<td>SPX</td>
<td>Bleeding</td>
<td>D2</td>
<td>Pancreas tail</td>
<td>Laparotomy</td>
<td>Alive</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>SPX</td>
<td>Bleeding Graft failure</td>
<td>D1 D3 D16</td>
<td>Splenic artery Short gastric artery</td>
<td>Laparotomy Re-laparotomy Re-LT using split DDLT</td>
<td>Dead (related sepsis)</td>
</tr>
<tr>
<td>5</td>
<td>9</td>
<td>SPX</td>
<td>Pancreatic fistula Bleeding</td>
<td>D1 D44</td>
<td>Pancreas tail Splenic artery</td>
<td>Pigtail drain SPA embolization</td>
<td>Alive</td>
</tr>
<tr>
<td>7</td>
<td>16</td>
<td>SPX</td>
<td>Bleeding Pancreatic pseudocyst</td>
<td>D7 D68</td>
<td>Splenic artery Splenectomy bed</td>
<td>SPA embolization Endoscop. internal drain</td>
<td>Alive</td>
</tr>
<tr>
<td>8</td>
<td>19</td>
<td>SDV</td>
<td>Bleeding</td>
<td>D7</td>
<td>Splenic flexure &amp; retrogastric wall</td>
<td>Laparotomy</td>
<td>Alive</td>
</tr>
</tbody>
</table>
Cumulative Experiences of SDV at AMC

- From August 2013 to September 2017
- Total number: 267 patients

- Complications related to SDV: 5 patients (1.9%)
  - PVT: 4 patients having huge spleen
    - Only 1 patient required Re-Operation for PV Thrombectomy
    - Improved with anticoagulation (Heparin $\rightarrow$ Warfarin)
  - Pancreatic leakage due to parenchymal injury: 1 patient
    - Improved with ERPD
  - Operation: 2 patients
    - PVT (1 patient)
    - Bleeding from splenic flexure & retrogastric wall (1 patient)
Summary (I)

• Splenectomy during LDLT

- The most effective method to improve CBC profiles.
- No demonstrable merits compared to SDV in view of small-for-size graft syndrome.
- Proximal ligation or embolization of SPAA is less invasive alternative options.
- DAA treatment for HCV has eliminated the necessity of splenectomy.
- Often results in lethal complications including bleeding and pancreatic fistula, particularly in case of poor pre-LT condition.
- High chance of post-OP thrombosis, but successfully managed by anticoagulation alone.
Summary (II)

- **Splenectomy during LDLT**
  - Not the best but acceptable method to improve CBC profiles.
  - No big difference compared to Splenectomy in view of small-for-size graft syndrome.
  - **Modified version of Proximal ligation of SPA** to treat SPAA.
  - Definite merits is **free from the procedure-related lethal complications** compared to Splenectomy.
  - Some risk of PostOP thrombosis in case of huge splenomegaly. Post-OP surveillance is necessary.
Conclusion

- Splenic Devascularization during LDLT is an innovative method to achieve acceptable results compared to Splenectomy.

- However, it has minimum procedure-related complications without lethal event.

- Hence, Splenic Devascularization could replace the role of splenectomy during LDLT from our experiences.
• Outcomes

• Splenic size: 평균+- SD구하기
• Small-for-size graft: Tbil 10mg/dL, Ascites 1L/d on postop day 7
• Complications
## Summary of the Treatment-related Post-OP Complications
(원본, study기간외에 포함된 것)

<table>
<thead>
<tr>
<th>No.</th>
<th>MELD</th>
<th>Tx.</th>
<th>Complication</th>
<th>POD</th>
<th>Site</th>
<th>Management</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SPX</td>
<td>Bleeding</td>
<td>D1</td>
<td>Splenectomy bed</td>
<td>Laparotomy</td>
<td>Alive</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SPX</td>
<td>Pancreatic fistula Aneurysm rupture</td>
<td>D1 D43</td>
<td>Pancreas tail Hepatic artery</td>
<td>Pigtail drain Laparotomy &amp; HA ligation</td>
<td>Dead (related sepsis)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>SPX</td>
<td>Bleeding</td>
<td>D2</td>
<td>Pancreas tail</td>
<td>Laparotomy</td>
<td>Alive</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>SPX</td>
<td>Bleeding Graft failure</td>
<td>D1 D3 D16</td>
<td>Splenic artery Short gastric artery</td>
<td>Laparotomy Re-laparotomy Re-LT using split DDLT</td>
<td>Dead (related sepsis)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>SPX</td>
<td>Pancreatic fistula Bleeding</td>
<td>D1 D44</td>
<td>Pancreas tail Splenic artery</td>
<td>Pigtail drain SPA embolization</td>
<td>Alive</td>
<td></td>
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<tr>
<td>7</td>
<td>SPX</td>
<td>Bleeding Pancreatic fistula Bleeding</td>
<td>D6 D7 D10</td>
<td>Pancreas tail Pancreas tail Pancreas tail</td>
<td>Laparotomy Pigtail drain SPA embolization</td>
<td>Dead (related sepsis)</td>
<td></td>
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<tr>
<td>8</td>
<td>SPX</td>
<td>Bleeding Pancreatic pseudocyst</td>
<td>D7 D68</td>
<td>Splenic artery Splenectomy bed</td>
<td>SPA embolization Endoscop. internal drain</td>
<td>Alive</td>
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<tr>
<td>9</td>
<td>SPX</td>
<td>SPA aneurysm</td>
<td>D11</td>
<td>Pancreas tail</td>
<td>SPA embolization</td>
<td>Alive</td>
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<tr>
<td>10</td>
<td>SDV</td>
<td>Bleeding</td>
<td>D7</td>
<td>Splenic flexure &amp; retrogastric wall</td>
<td>Laparotomy</td>
<td>Alive</td>
<td></td>
</tr>
</tbody>
</table>