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German Procurement Guidelines

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DTG Procurement Guidelines in Heart Beating Donors

Introduction

Guideline for Liver procurement

1. Preparation
1.1. Check-list
1.2. Position of the donor
2. Procurement Technique
2.1. Dissection in the cold
2.1.1. Incision
2.1.2. Exploration
2.1.3. Cannulation and retrieval preparation
2.1.4. Exposure of thoracic/abdominal aorta
2.1.5. Cannula insertion
2.1.6. Perfusion
2.1.7. En bloc liver and pancreas removal
2.1.8. En bloc removal of kidneys
2.1.9. Removal of iliac arteries and veins
2.1.10. Back table split of liver and pancreas following en bloc kidney removal
2.2. Warm dissection technique
2.2.1. Exposure of abdominal aorta/common iliac artery and IVC
2.2.2. Exposure of thoracic/abdominal aorta
2.2.3. Removal of Liver
2.2.4. Removal of Pancreas
2.2.5. Removal of Kidneys
2.2.6. Removal of iliac arteries and veins
2.3. Kidney only retrieval
2.4. Back Table
2.5. Organ packing
2.6. Postprocurement care of donor

Guideline for Kidney procurement

1. Preparation
1.1. Check-list
1.2. Position of the donor
2. Procurement Technique
2.1. Incision
2.2. Exploration
2.3. Cannulation and retrieval preparation
2.4. Cannula insertion
2.5. Perfusion
2.6. Kidney removal
2.7. Organ packing
2.8. Postprocurement care of donor

Guideline for Pancreas procurement

1. Preparation
1.1. Check-list
1.2. Donor age
1.3. Donor Body Mass Index (BMI)
2. Procurement Technique
2.1. Incision
2.2 Exploration
2.3. Perfusion
2.4. Organ packing

Guideline for small intestine procurement

1. Preparation
1.1. Patient selection
1.2. Donor Criteria
1.3. Donor preparation
2. Procurement Technique2.1. Preliminary remark
2.2. Operative procedure
2.3. Perfusion
2.4. Organ retrieval
2.5. Organ packing

Guideline for multivisceral procurement

1. Preparation
1.1. Patient selection
1.2. Donor criteria
1.3. Donor preparation
2. Procurement Technique
2.1. Preliminary remark
2.2. Operative procedure
2.3. Perfusion
2.4. Organ retrieval
2.5. Organ packing

Guideline for Heart procurement

1. Preparation
1.1. Check list
1.2. General comments for donor selection
1.3. Unsuitable marginal donors
1.4. Patients position on the operation table
2. Procurement Technique
2.1. Operative technique
2.2. Postprocurement care of donor

Guideline for Lung procurement

1. Preparation
1.1. Members of the thoracic procurement team
1.2. Equipment
1.3. Transportation
1.4. Responsibilities for the thoracic team and general assessment
1.5. General assessment of thoracic organs
1.6. Communication
2. Procurement Technique
2.1. Heart and lung preparation and perfusion
2.2. Heart dissection
2.3. Lung dissection
2.4. Heart-lung bloc dissection
2.5. Back table preparation and package
3. Leaving the donor hospital

The donor transplant coordinator arranges the transport of the surgical team to and from the donor hospital. Within the EU region, it is advisable to bring personal ID (e.g. passport). Separate arrangement of transport for the thoracic procurement team is necessary because of reduced cardiac and pulmonary ischemic tolerance.

After arrival in the donor hospital, the procurement surgeon introduces him- or herself and the procurement team. It is important to communicate with all persons and teams involved in the organ retrieval process to ensure a smooth running retrieval process is achieved. The procurement surgeon has to control all relevant donor charts and documents (patient identification, certification of brain death, death certification, organ donation consent, blood type, serological results and risk factors etc.)

Organ procurement for transplantation should be performed in a peaceful and dignified atmosphere generally. The remaining wishes of the organ donor or the relatives must be respected unconditionally. In general, a dignified and respectful treatment of the organ donor is a condition sine qua non for each person involved in process of organ donation.

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GUIDELINE FOR LIVER PROCUREMENT

1. Preparation

Before the organ donation procedure can be started, the retrieving surgeon has to check and confirm:

1.1. Check-list

- Brain death tests
- Blood group
- Serology (Hep B, Hep C, CMV, EBV, Toxoplasmose)
- Organ specific blood results
- Recent hemodynamic history/vasopressors requirements
- duration of ICU stay
- number and period of down times
- Insulin requirements (dosage)
- medical history
- donor skin for tumours
- rectal examination (and prostate for male) for pathology
- Intraoperative liver ultrasound scan if available

1.2. Position of the donor

- Arms aside
- Head reclined
- Hair removal from jugulum to symphysis
- Sterile drapes and opsite foyle

2. Procurement technique

In principle, there are three different techniques to retrieve abdominal organs.

2.1. Rapid technique "**dissection in the cold**" (mandatory for unstable donors). This technique minimizes operating time.

2.2. "**warm dissection technique**" in which dissection of organs takes place before cannulation and perfusion. There is evidence that dissection prior to perfusion causes vasospasm and increased oxygen consumption of the abdominal organs (especially the liver). To compensate for this, the time needed by the thoracic retrieval team will allow for reversing of these changes. Once thoracic organs are not being allocated, a recovery period of 30–60 min should be implemented for compensation in case the warm dissection technique is applied.

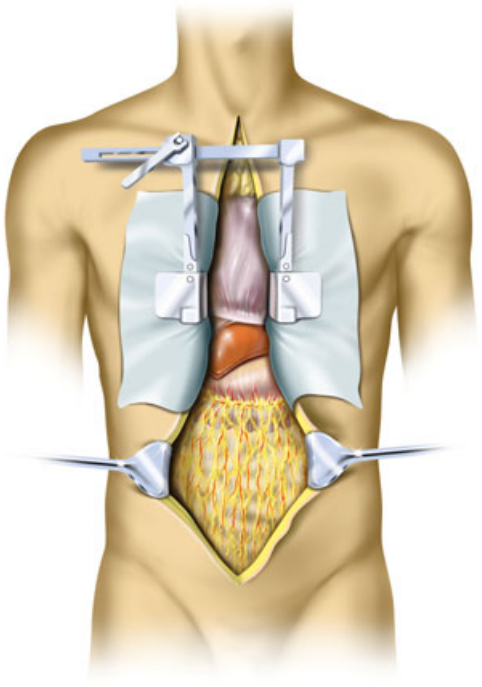
2.3. Kidney only retrieval (see guideline for kidney procurement)

2.1. "Dissection in the cold" (Rapid retrieval technique)

2.1.1. Incision

Best access is obtained via a midline thoraco- and laparotomy, even if heart and lungs are not to be retrieved, from jugulum to symphysis. In case of donor hemodynamic instability thoracotomy can be delayed until perfusion has been established.

For best hemostasis, use of diathermy for all layers including skin is to be recommended.



Sternotomy and laparotomy:

1. Blunt dissection of jugular fossa and subxyphoideal praecardial region
2. Diathermy transsection of retrojugular ligament
3. Sternotomy
4. Hemostasis of sternum using bone marrow wax
5. Pericardium to be left closed until cardio-thoracic teams have arrived and agreed to open it
6. Self-retaining retractor for thorax and abdomen (in case of tension incision of diaphragm lateral to both sides of the pericardium)
7. Longitudinal opening of pericardium from apex of heart to vena anonyma. (check with cardio-thoracic team before opening)
8. Fixation of pericardium to suprasternal skin with 2 2–0 Vicryl stitches on each side

2.1.2. Exploration

All abdominal and thoracic organs are to be checked for pathologies.

2.1.3. Cannulation and retrieval preparation

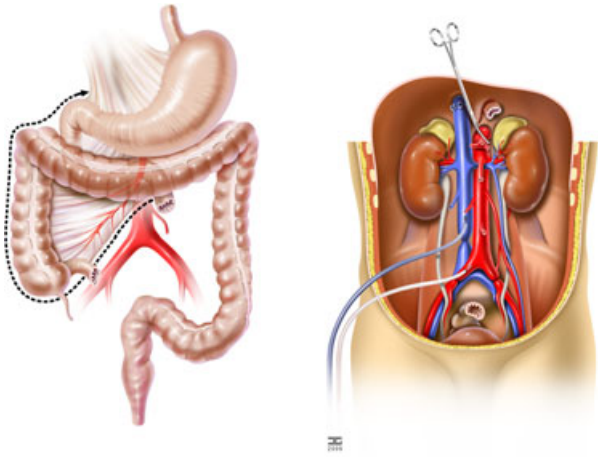
Exposure of abdominal aorta/common iliac arteries (CIA) and inferior vena cava (IVC)

1. Incision of peritoneal duplicature of distal ileum and cecum.
2. Complete exposure of retroperitoneum following mobilization of right hemicolon and Kocher's maneuver of the duodenum.
3. Complete exposure of infrahepatic IVC from aortic bifurcation to upper margin of left and right renal vein.
4. Identification of aortic bifurcation and proximal common iliac arteries.

Nota bene: In 1–3% of individuals lower pole renal arteries arise from the CIA. Especially in this case, the right common iliac artery should be cannulated below origins of lower pole arteries. Additionally, another tie has to be put around the left CIA, for later closure, to avoid perfusion solution loss going into the left lower extremity. Ties should only be knotted and the CIA or aortic cannula inserted 3 min after administration of heparin (25 000 units or 300 mg/kg bodyweight).

5. Dissection of aorta and two slings around it for later securement of perfusion cannula. Preservation of inferior mesenteric artery (IMA) for pediatric and split liver transplantations. If applicable the IMA is to be retrieved with an aortic patch following organ retrieval.
6. One tie around distal IVC (to prevent blood back flow from lower extremities during perfusion).

Nota bene: In case of severe arteriosclerosis of the abdominal aorta or CIA the perfusion cannula is to be positioned into the distal aorta. If the distal abdominal aorta is not useable in case of severe arteriosclerosis or aneurysms, the thoracic aorta should be used for perfusion access to avoid thromboembolisms or false cannulation.



2.1.4. Exposure of thoracic/abdominal aorta

To enable separate perfusion of abdominal and thoracic organs later on, the aorta needs to be encircled in height of the diaphragm for cross-clamping. Before the thoraco-abdominal transition of the aorta is exposed, the anatomy of the hepatic artery should be investigated by gentle manual examination.

Mobilization of left liver lobe

The left triangular ligament is to be dissected with complete subdiaphragmatic mobilization until the suprahepatic IVC becomes visible. At this point of time, check for accessory/aberrant left hepatic artery arising from the left gastric artery running through the lesser sack.

Control of aorta

In order to achieve control of the aorta, the diaphragmatic hiatus just right of the esophagus should be openend. Retraction of the esophagus to the left provides exposure of the aorta. Incision of periaortic serosa and retroaortic blunt dissection with a large blunt right angle will enable placement of a heavy tie or nylon tape around the aorta for later safe and complete cross-clamping. Be aware of lumbal arteries while dissecting the posterior aspect of the aorta.

Before inserting the perfusion cannula pause for the thoracic team. Protect abdominal organs with wet abdominal swabs, with one member of the abdominal team required to stay at operating table. Once thoracic team is ready for perfusion 25 000 IE units (or 300 U/kg bodyweight) heparin should be administered at least 3 min before cannulation.

2.1.5. Cannula insertion

First step is the Ligation of left common iliac artery. Ligation of distal right common iliac artery or distal aortic tie. T-shape incision of CIA/aorta and insertion of connected and flushed cannula. Ligation of proximal tie including the tip of perfusion cannula and double securement of inserted perfusion cannula.

2.1.6. Perfusion

In agreement with thoracic team, cross-clamping of thoracic aorta and incision of suprahepatic IVC (for venting) will precede pressure perfusion of the aorta only. Dual perfusion, i.e. additional portal venous perfusion has been shown to be hazardous for pancreas and small bowel grafts and of no clinical benefit for the liver. If the receiving liver centre insists on dual perfusion, the portal venous catheter is to be inserted into the portal vein well above the duodenum. This will allow venting of the portal venous system below the portal venous cannula to provide outflow, which is of particular importance when pancreas and/or small bowel are to be retrieved. To avoid any risk of outflow obstruction, the portal vein should be transsected completely, just inferior of the portal vein cannula. With the start of perfusion, an immediate topical cooling of all abdominal organs with ice cold saline and/or slush ice is recommended. During perfusion the cystic duct is to be identified and suture ligated for prevention of gallbladder bile draining into the bile ducts. If time allows (thoracic team is still busy) opening of the common bile duct (CBD) above the duodenum and intensive (>100 ml cold saline, 0.9% lidocaine or perfusion solution) washout until the effluat is clear. The distal part of the CBD (toward the pancreas should be suture ligated. Rinsing of bile ducts is to be repeated once back table preparation is finished before packing of the liver).

Abdominal organs are usually retrieved following removal of the thoracic organs (see guidelines for heart and lung procurement)

2.1.7. En bloc liver and pancreas removal (see guideline for pancreas procurement)

En bloc liver and pancreas removal involves:

* Incision of the diaphragm on the left side until the esophagus, on the right side until the adrenal gland with much care not to cause lesions to the right liver capsule due to traction.
* Division of the right gastro-epiploic and right gastric artery using ligation.
* Stapling of the proximal duodenum directly distally to the pylorus using a 80 mm GIA blue stapler magazine. Betadine swaps for stapler lines.
* Ligation of the left gastric artery and vein.
* Clipping, ligation of the inferior mesenteric vein at the distal border of the pancreas.
* Dissection and transsection of the superior mesenteric artery and vein at the 3rd part of the duodenum next to the inferior part of the head of the pancreas. The mesenteric root can be transsected using a GIA stapler (reload). The stapler line should not be too close to the lower part of the uncinate process to avoid incidental injury/closure of the pancreatico-duodenal artery.
* Stapling of the proximal jejunum distal to the ligament of Treitz using a reload for the 80 mm GIA stapler. Betadine swaps for stapler lines.
* Transection of the spleno-colic ligament while lifting up the tail of the pancreas using the spleen as a handgrip.
* Mobilization of the dorsal side of the pancreas using electrocautery.
* Dissection of the aortic part of the superior mesenteric artery under visualization of the left and right renal arteries.
* Freeing of the infrahepatic IVC displaying the origins of the right and left renal veins and transsection of the IVC just above the renal veins.
* Divison of the right paravertebral muscle layer and transsection of the right adrenal gland.
* Division of the left paravertebral muscle layers and transsection of the left adrenal gland up to the sling/clamp of the proximal aorta.
* Release of the bloc is complete once the prevertebral connective tissue is divided and the SMA is cut out with the proximal aorta including the coeliac trunc. Special care must be taken here not to injure the main renal arteries because of their proximity to the SMA.

2.1.8. En bloc removal of kidneys (see guideline for kidney procurement)

2.1.9. Removal of iliac arteries and veins

Procurement of iliac arteries (CIA, EIA and IIA) and veins as a tool kit for both liver and pancreas (or intestine) should include the 2nd degree branches of the internal iliac artery. In case of severe arteriosclerosis, procurement of the brachiocephalic truncs is to be performed additionally.

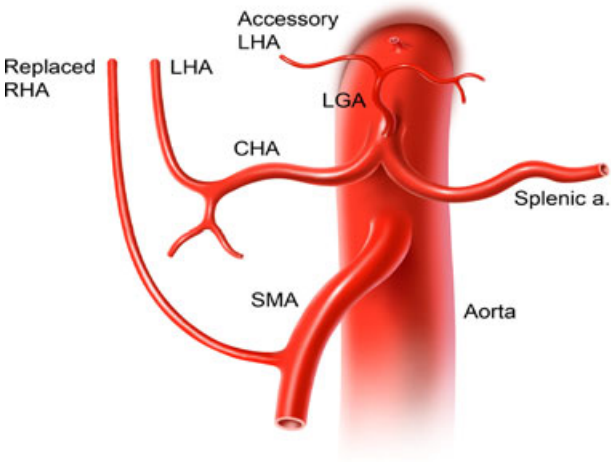
Furthermore, if no small bowel is being allocated, the entire mesenteric root can be left attached to the pancreas providing the ilieocolic artery for direct revascularization to the splenic artery.

The retrieval ends with meticulous and watertight closure of the thoraco-and laparotomy and neat skin closure and decent wound dressings.

2.1.10. Back table split of liver and pancreas following en bloc kidney removal

Back table split of liver and pancreas starts with:

* The separation of liver and pancreas begins with the division of the common hepatic artery and superior mesenteric artery.
* Suture marking (toward the pancreas) of the gastroduodenal artery at the upper border of the head of the pancreas with consecutive transsection of the GDA leaving a stump at the common hepatic artery.
* The bloc is further divided by cutting of the splenic artery close to the celiac trunc. Following placement of an identification stich (6–0 Prolene) at its distal part transsection of the splenic artery in the middle of its origin and its first branch for the pancreas.
* Transsection of the portal vein well above the confluence of the splenic and superior mesenteric vein will leave a sufficient amount of the portal vein for the liver as well as for the pancreas.



* An aberrant/accessory right hepatic artery might appear dorsally of the portal vein. (if present ligation of right hepatic artery at its origin preserving the SMA for the pancreas).
* The division of liver and pancreas ends with ligation of the distal ductus choledochus and its transsection. At this point of time an additional rinse of the hepatic bile ducts is recommended.

2.2. Warm dissection technique

This technique has been shown to be more time consuming. Additionally, it is associated with a higher rate of parenchymal and vascular injuries as well as with inferior graft function of liver and pancreas.

Complete exposure of retroperitoneum following mobilization of right hemicolon and Kocher's maneuver.

2.2.1. Exposure of abdominal aorta/common iliac artery and IVC

Exposure of abdominal aorta/common iliac artery and IVC includes:

* Incision of peritoneal duplicature of distal ileum and cecum.
* Complete exposure of retroperitoneum following mobilization of right hemicolon and Kocher's maneuver.
* Complete exposure of infrahepatic IVC from aortic bifurcation above left renal vein.
* Identification of aortic bifurcation and proximal common iliac arteries.

CAVE: In 1–3% lower pole renal arteries arise from CIA. In this case the right common iliac artery should be the place for cannulation just below the lower pole artery. In this situation, another tie has to be put around the left CIA for later closure to avoid perfusion going into the left leg. Ties should only be knotted and the CIA or aortic cannula inserted at least 3 min after administration of heparin (25 000 units).

* Dissection of aorta and 2 slings around it for later securement of perfusion cannula. Preservation of inferior mesenteric artery for pediatric and split liver transplantations. In case to be retrieved with an aortic patch following organ retrieval.
* One tie around distal IVC (to prevent blood back flow from lower extremities during perfusion).

In case of severe arteriosclerosis, the cannula is to be positioned into the distal aorta. If distal abdominal aorta is not useable in cases of most severe arteriosclerosis or aneurysms, the thoracic aorta should be prepared for perfusion access rather than to risk thromboembolisms or false cannulation.

2.2.2. Exposure of thoracic/abdominal aorta

To enable later on separate perfusion of abdominal and thoracic organs, the aorta needs to be encircled in height of the diaphragm.

1) Mobilization of left liver lobe

The left triangular ligament is to be dissected with complete subdiaphragmatic mobilization until the suprahepatic IVC. At this point of time check for accessory/aberrant left hepatic artery arising from the left gastric artery.

2) Control of aorta

Control of aorta includes the following: Opening of the diaphragmatic hiatus just right to the esophagus/cardia. Retraction of the esophagus to the left. Incision of periaortic serosa and retroaortic blunt dissection with a large

blunt right angle. Placement of a heavy tie or nylon drape around the aorta.

3) Dissection of hepatoduodenal ligament (distally to preserve bile duct arterial perfusion) with identifying of the gastroduodenal artery and dissection of the common hepatic artery in proximal direction.

Identification of the left gastric artery and splenic artery.

Ligation of cystic duct. (Cholecystectomy to be performed in transplant center).

Dissection of the coeliac trunc.

Dissection of proximal superior mesenteric artery.

4) Once thoracic team is ready for perfusion administration of 25 000 units of heparin (or 300 units/kg bodyweight) 3 min before cannula insertion.

Cannula insertion of right CIA or aorta and pressure perfusion.

In case no small bowel or pancreas is being retrieved, additional portal vein perfusion can be performed (CAVE: low pressure to avoid sinusoidal damage).

To achieve good exposure of liver and pancreas, stapling of the proximal duodenum directly distally to the pylorus using a GIA blue stapler magazine. Stapling of the mesenteric root using GIA stapler (reload). The line for stapling should not be too close to the uncinate process in order to avoid incidental injury/closure of the pancreaticoduodenal artery. Stapler transsection of proximal jejunum.

2.2.3. Removal of Liver

Removal of Liver includes the following: Placing the stomach into the thorax and the gut between the legs for complete exposure of liver, pancreas and kidneys.

Transsection of GDA and suture marking of distal part (toward the pancreas).

Tanssection of splenic artery and suture marking of distal part (pancreatic side).

Excision of celiac trunk with an aortic patch/or proximal aorta.

Transsection of portal vein and suture marking of distal part (pancreas side).

Transsection of infrahepatic IVC just above left renal vein.

Excision of liver with diaphragm. Transsection line should go through right adrenal gland and around suprahepatic IVC.

Liver to be placed in bowl with ice cold water.

2.2.4. Removal of Pancreas (see guideline for pancreas procurement)

Removal of Pancreas includes:

Upward transsection of aorta just distally of SMA (CAVE: very close relationship to renal artery orifices).

Excision of spleen and dorsal aspect of pancreas. The spleen should be used as a handgrip. Material for X-match can be taken from upper and lower pole of the spleen, but the main remnant of the spleen should be kept with the pancreas graft.

Pancreas to be placed in bowl containing ice cold water.

2.2.5. Removal of Kidneys (see guideline for kidney procurement)

2.2.6. Removal of iliac arteries and veins

Procurement of the iliac arteries and veins as a tool kit for both liver and pancreas is mandatory. The 2nd degree branches of the internal iliac artery should be dissected and transsected. In case of severe arteriosclerosis, procurement of the brachiocephalic arteries is to be performed additionally.

If no small bowel is allocated, the entire mesenteric root can be left attached to the pancreas providing the ilieocolic artery for direct revascularization of the splenic artery.

The retrieval ends with meticulous and watertight closure of the thoraco-and laparotomy and neat skin closure and acceptable wound dressings.

2.3. Kidney only retrieval (see guideline for kidney procurement)

2.4. Back table

All retrieved organs are to be perfused on the back table (liver arterial perfusion using pressure to prevent ITBL).

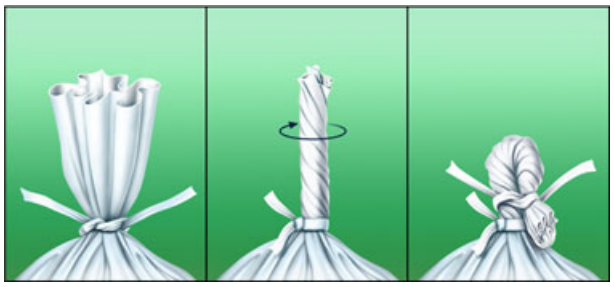
All organs are to be checked for vascular, capsular or parenchymal injury which should be reported in any case.

2.5. Organ packing

1st bag: liver in perfusion solution (temperature 4 °C)
2nd bag: sterile ice cold Ringer's lactate or saline
3rd bag: nil

Retrieved vessels should be put into an extra bag filled with perfusion solution.

No air or ice in any bag.



2.6. Postprocurement care of donor

Postprocurement care of donor involves the following:

1. Removal of all foreign materials and residual fluid
2. Wound closure with sutures (meticulous and watertight)
3. Neat skin closure
4. Wound dressing
5. Removal of all underlying derivations
6. Dignified and respectful transfer of the cadaver

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GUIDELINE FOR KIDNEY PROCUREMENT

1. Preparation

The following points and procedures shall apply for isolated renal explantation as well as for the multi organ explanation approach.

1.1. Check-list

- Patient identification (donor transplant coordinator)
- Death certificate
- Certification of brain death
- Organ donation consent
- Blood type
- Viral status
- Laboratory values (including blood count, electrolytes, creatinine, urea, blood–gas analysis)
- Patient history
- Radiology charts
- Intensive care medication (especially use of catecholamine etc.)
- Urine

1.2. Position of the donor

- Slightly overstretched supine position
- Both arms released sideways
- Head reclined
- Shaving the jugular area to the symphysis
- Disinfection and sterile covering

2. Procurement technique

2.1. Incision

Transperitoneal access approach should be performed as far as possible as median laparotomy, if necessary with thoracotomy in obese patients.

2.2. Exploration

After transaction of the ligament teres hepatis and ligament falciforme, the palpation of the abdomen has to be performed to rule out gross pathologies (in particular tumors/malignancy, infection and injury) and to evaluate the donor organs.

2.3. Cannulation and retrieval preparation

Exposure of the abdominal aorta and common iliac artery on both sides.

1) Pull the right colon to the left side and cut the posterior peritoneum for mobilization of the ascending and transverse colon up to hepatic hilum.
2) Exploration and secure identification of the ureter.
3) Kocher manoeuver.
4) Exposure of the inferior vena cava from the bifurcation up to the renal veins.
5) Looping of the inferior vena cava below the renal veins.
6) Exposure of the aortic bifurcation and the common iliac arteries.

Nota bene: in up to 3% of organ donors lower renal pole artery aberration is seen, which takes its origin from the iliac arteries.

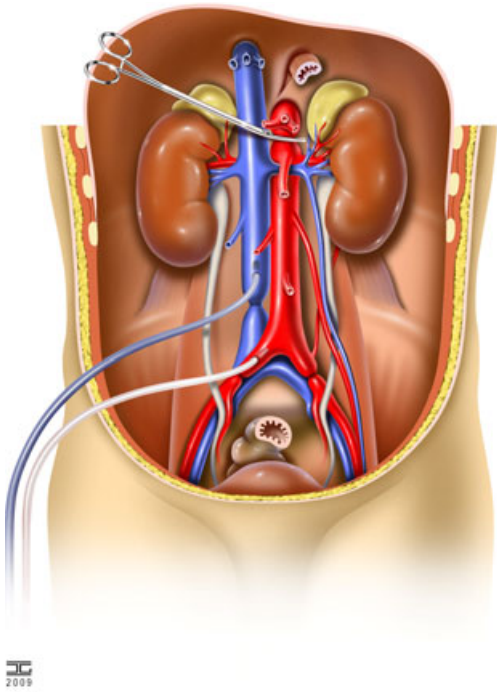
After freeing the anterior wall the aorta is dissected proximally to the superior mesenteric artery.

Nota bene: the left renal vein should be considered.

7) Looping of the superior mesenteric artery and ligature of the inferior mesenteric artery.
8) Looping of the common iliac arteries and distal ligature (place 2 additional Vicryl strings above the ligature to the right for 22–24 F perfusion cannula).

2.4. Cannula insertion

After clamping the vessel, the insertion of the perfusion cannula into the right common iliac artery or into the abdominal aorta (below the inferior mesenteric artery) should be performed first. Here, it is essential to exclude the presence of aberrant lower pole renal arteries. A large-lumen perfusion catheter (22–24 F), which is already connected to a perfusion system and flushed with perfusion solution, is to be placed correctly. Fix cannula with ligature around vessels to avoid blood leakage..



2) Weight optimized heparin i.v. application (300 IU/kg bodyweight) with 3 min stand-by.
3) Ligate or clamp the aorta with aortic clamp above the superior mesenteric artery.

Nota bene: avoid injury of the left lever lobe parenchyma.

4) Ligature of the inferior vena cava close to the bifurcation.
5) Start perfusion with preservation fluid (150 mmHg pressure, temperature 4 °C) through the right common iliac artery and abdominal aorta.
6) Incision of the inferior vena cava above the ligature and below the renal veins with aspiration of venous blood. Alternatively, insertion of 24 F catheter into the vena cava.
7) Immediate topic cooling of the abdominal organs with sterile Ringer's lactate or 0.9% NaCl solution (temperature 4 °C) and ice slush.

Nota bene: Check quality of organ perfusion.

2.5. Perfusion

1) Looping of the aorta above the superior mesenteric artery, if necessary ligate and cut the superior mesenteric artery.

If approaching the aorta above the celiac trunk: Mobilise the left liver lobe by cutting the triangular ligament (CAVE: left aberrant hepatic artery) and subsequently cut through the diaphragm muscle to reach the aorta (CAVE: the esophagus).

2.6. Kidney removal

1) At the end of perfusion, proceed to ventral opening of the cava inferior above the ligature up to the renal veins

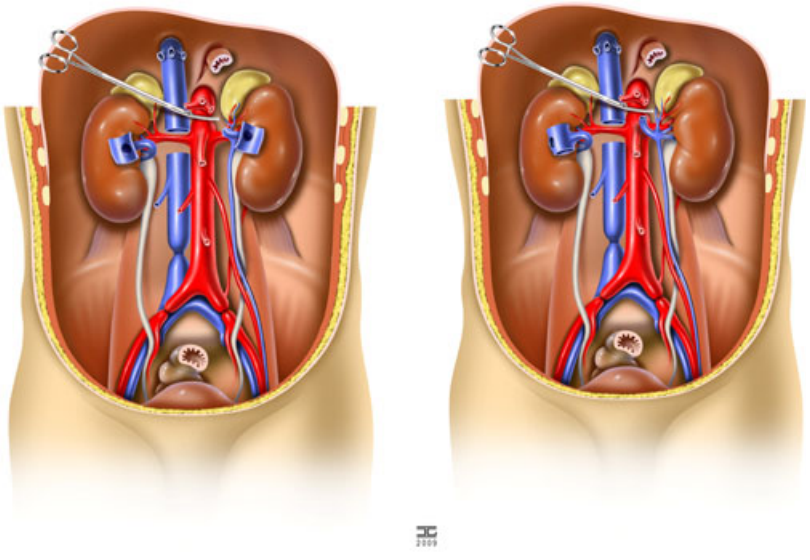
Nota bene: the presence of an atypical precaval renal artery on the right side should be considered.

2) Dorsal incision of vena cava inferior.

Nota bene: dorsal intersecting of the right renal artery.

Alternatively, after preparation of all main renal veins, it is possible to leave the inferior vena cava tube-shaped to the right renal vein.

3) Dissection of both renal veins patches laterally (left-side lateral to the aorta).
4) Ventral opening of the aorta abdominalis from the bifurcation just above superior mesenteric artery.



5) Localization the ostia of renal arteries.

Nota bene: potential aberrant artery outlets between superior mesenteric artery and iliac artery

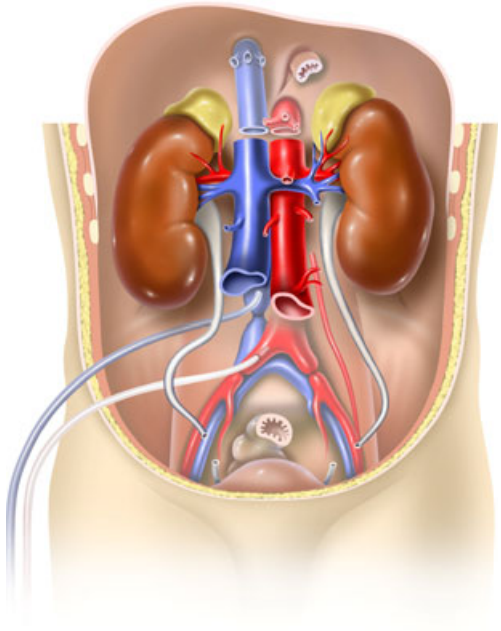
6) Incision of the dorsal wall of the aorta in between the lumbar arteries.
7) Dissection of both renal artery patches laterally.
8) Removal of the kidney including adiposa capsule, vascular patches and ureter (cut ureter close to the urinary bladder). Put each kidney in sterile container with 4 °C solution.

Alternatively, after exposing all renal vessels the *en block* removal of the kidneys could be performed.

En block removal of the kidneys

Following incision of the retroperitoneum, the sigmoid is to be lifted up and transsection of the left mesocolon follows. The next step is the dissection and transsection of the ureters close to the bladder. Incision of the left perirenal fat will mobilize the left kidney. Both ureters are to be lifted up together with the ICV and distal aorta. Dissection of the retroperitoneal tissue will provide the kidneys en bloc.

Back table separation of the kidneys starts with cutting out the left renal vein including a patch of the IVC. This will leave most of the IVC with the right renal vein. The kidney bloc has to be turned over for transsection of the posterior aorta in between the lumbar arteries. Division of the aorta will be completed by transsection of the anterior wall of the aorta under clear view of renal arterial orifices and potential additional arteries, preserving patches for all.



For organ evaluation Back table pressure perfusion of kidneys is necessary in order to check for clear flush and potential vascular injuries.

Nota bene: By donors ≤5 years the kidneys should be removed "*en block*" including complete abdominal aorta and vena cava inferior. In such cases, it is important to communicate with the acceptor center.

9) Back-table surface exposure of the kidney is mandatory to exclude a tumor presence and to evaluate the perfusion status of the kidney (beginning on the convexity of the kidney).

Nota bene: centralized preparation and preparation between the lower pole of the kidney and ureter is to be avoided (CAVE: blood supply of the ureter).

10) Finally, additional perfusion should be performed to assess the perfusion quality and the vascular status of each renal artery. The venous outflow is to be assessed individually.

2.7. Organ packing

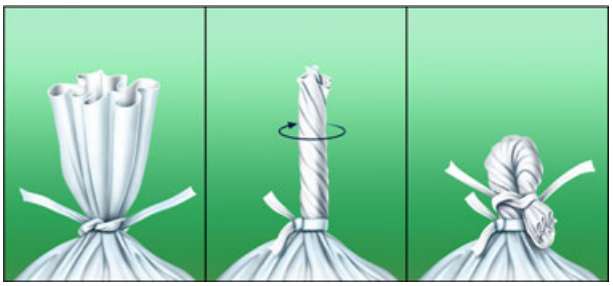
Each kidney is stored in three separate bags.

1st bag: left/right kidney in cold preservation solution (500 ml, temperature 4 °C)

2nd bag: sterile ice cold Ringer's lactate or saline (1000 ml, temperature 4 °C)

3rd bag: sterile ice cold Ringer's lactate or saline (1000 ml, temperature 4 °C) and label *left/right side*

The organs are to be placed into the transport box with crushed ice. Add blood specimens and one piece (8–10 cm^3) of spleen (alternatively, in case of absent spleen, lymph nodes) in a box with cold Ringer's lactate or saline.



2.8. Postprocurement care of donor

1. Removal of all foreign materials and residual fluid
2. Wound closure with solid sutures (meticulous and watertight)
3. Neat skin closure
4. Wound dressing
5. Removal of all underlying derivations
6. Dignified and respectful transfer of the cadaver

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GUIDELINE FOR PANCREAS PROCUREMENT

1. Preparation

Before the start of the pancreas procurement, the following data should be checked and considered by the explantation team as well as by the team at the recipient center:

1.1. Check-list

The following data should be checked to ensure there is no impaired pancreas graft function:

ICU stay >7 days
Cardiac arrest >5 min
Sodium >160 mmol/l
Amylase >390 U/l or Lipase >480 U/l
(Nor) adrenaline >0.05 μg/kgBW/min or Dobuta-/dopamine >10 μg/kgBW/min

1.2. Donor age

There are some data that a donor age >50 years seems to be critical for the long-term pancreas graft survival. Andreoni et al. [1] reported a significantly reduced 5-year graft survival with donors older than 50 years (60%) compared with those organs from donors aged between 18 and 34 years (73%). Therefore, Eurotransplant introduced an upper age limit for pancreas donors which is 50 years. Donors older than 50 years should be considered for islet transplantation.

1.3. Donor Body Mass Index (BMI)

Obese donors may have a higher content of pancreas fat and may therefore be more susceptible to the ischemia-reperfusion injury (IRI), as well as intra-abdominal infections and early graft loss.

Stegall et al. [2] performed an analysis including donors with BMI above 30 compared with donors with a BMI <30. The 3-year pancreas graft survival was 68% from donors with a BMI >30 and 78% from donors with BMI <30, respectively. Hence, the graft survival from the obese donors was significantly reduced.

Eurotransplant offers only donors with a BMI ≤30 for pancreas transplantation. Obese donors (BMI >30) should be considered for islet transplantation.

All these aforementioned data are also reflected in the P-PPAS-Score (preprocurement pancreas suitability score) defined by Vinkers et al. [3] (see also Table 1), whereby donors with a P-PPAS score <17 should be accepted for pancreas donation.

Table 1. P-PPAS-Score.

	1 Point	2 Points	3 Points
Age (years)	<30	30–40	>40
BMI (kg/m^2)	<20	20–25	>25
Serum sodium (mmol/l)	<155	155–160	>160
ICU stay (d)	<3	3–7	>7
Cardiac arrest (min)	No	<5	>5
Amylase (U/l) *or*	<130	130–390	>390
Lipase (U/l)	<160	160–480	>480
(Nor)adrenaline (μg/kgBW/min) *or*	No	<0.05	>0.05
Dobuta-/dopamine (μg/kgBW/min)	No	<10	>10

2. Procurement technique

2.1. Incision

The thoraco-abdominal access was described previously (see guideline for liver procurement).

2.2 Exploration

Verification of the vascular anatomy of the upper abdomen (variations of the norm, such as branching of the right hepatic artery from the superior mesenteric artery or of the left hepatic artery from the left gastric artery).

Preparation of the pancreas with no-touch technique with the mobilized spleen as ''handle'', visualization of the branches of the celiac trunk and the superior mesenteric artery for clarification of vascular variations (see also Fig. 1).

2.3. Perfusion

The arterial perfusion of the pancreatic head is via the superior pancreaticoduodenal artery from the celiac trunk and the inferior pancreaticoduodenal artery from the superior mesenteric artery (ventral and dorsal branch each). Furthermore, there is the wide dorsal pancreatic artery with common variations of the branching (proximal splenic artery, superior mesenteric artery, common hepatic artery and celiac trunk).

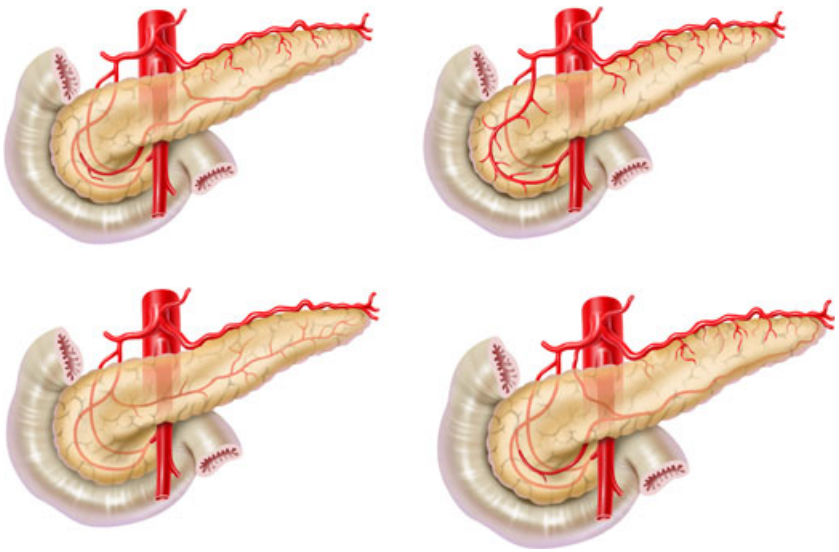

Figure 1 Variations of the arterial blood supply of the pancreas.

For the vascular reconstruction the following have to be preserved: Splenic artery, superior mesenteric artery, dorsal pancreatic artery.

In combined liver-pancreas explantation, the celiac trunk has to remain with the liver graft in case of need for the liver recipient. Nevertheless, if at all possible, a sufficiently large part of the splenic artery should be preserved. Moreover, the dorsal pancreatic artery should be preserved under all circumstances with the pancreas graft, with its artery of origin, if possible. In case of donor 3-vessel perfusion of the liver an aortic patch including both arteries of origin has to remain with the liver graft. In this case, the arterial and venous iliac bifurcation has to remain with the pancreas graft.

The next steps have to be done as follow:

- After the start of perfusion, transection of the mesenteric root. Eventeration of the bowel convolute. In case of large perfusion volumes, possibly radicular clamping of the splenic artery or the superior mesenteric artery. Normally in situ preparation, ex situ preparation in case of an un-stable donor or difficult vascular conditions. Packing of the organs as with the liver. Donor vessels (common iliac artery and vein with bifurcation) should be collected.

Perfusion solution

There were many controversies about the ''ideal'' preservation solution during pancreas procurement. In a retrospective analysis performed by Becker et al. [4], there was no significant difference between histidine-tryptophan-ketoglutarate (HTK) and University of Wisconsin (UW) solution. Both solutions have been shown to be safe for pancreas preservation.

So, in western Europe the routinely used HTK solution might have no impact on the post-transplant pancreas graft function.

2.4. Organ packing

1st bag: liver in perfusion solution (temperature 4 °C)
2nd bag: sterile ice cold Ringer's lactate or 0.9% NaCl solution
3rd bag: nil

Retrieved vessels should be placed in an extra bag including perfusion solution attached to 1st bag.

No air or ice in any bag.

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A. PASCHER, BERLIN

GUIDELINE FOR SMALL INTESTINE PROCUREMENT

1. Preparation

Before the start of the small intestine procurement, the following data should be checked and considered as well by the explantation team as well as by the team of the recipient center:

1.1. Patient selection

Cause of death/resuscitation/shock
Crossmatch
HLA-Matching
Viral status
Laboratory: liver enzymes, cholestasis parameters, lipase, sodium, creatinine, BUN, CRP, WBC, RBC, PLT
Vasopressor therapy
Need for packed red blood cells, fresh frozen plasma
Volume therapy
Duration of ICU-stay
Kidney function
Medical history
Enteral nutrition?

1.2. Donor criteria

Age	≤45 years
Intensive care	≤5 days, enteral nutrition desirable
Height/body weight	BMI ≤25 Matching with recipient
Crossmatch	Negative
Cold ischemia	≤6 h
Cause of death/ Medical history	Exclusion criteria: – Blunt/sharp abd. trauma with operative procedures, e.g. splenectomy – Asphyxia, CO-intoxication – Resuscitation, long duration of hypotension – Shock – Large blood losses; high amounts of packed RBC – Alcoholism, i.v.-drug abuse – Arteriosclerosis – Diabetes mellitus – History of operative procedures of the small intestine – State after peritonitis – High amounts of vasopressors
Laboratory	Sodium <150–155 mmol/l Caveat: elevated liver enzymes/lipase after trauma No CMV high risk constellation

1.3. Donor preparation

* Brain death protocol
* Informed consent
* Steroid premedication
* Crossmatch
* Examination of skin
* Rectal digital examination

2. Procurement technique

(Simultaneous Pancreas/Intestine)

2.1. Preliminary remark

Simultaneous intestine/pancreas procurement should be performed by the center performing the intestinal transplant;

Laparotomy should commence in the presence of the intestinal team.

2.2. Operative procedure

- Median laparotomy and sternotomy from jugulum to symphysis
- In case of ascites:
  Asservation of ascites (microbiology, cytology and biochemistry)
- Insertion of thoracic retractor

- Separation of Ligg. teres hepatis and falciforme

Judgement of small intestine

- General state of organ (edema, congestion and hematoma)
- Motility
- Adhesions, peritonitis
- Angiodysplasias, petechial bleeding and signs of contusion

At this point start of recipient operation in the case of a negative crossmatch

- Dissection of adhesions of colon/spleen to the parietal peritoneum
- Abdominal retractor system
- Exploration of abdomen and exclusion of any organ pathologies

Caveat: further operative steps should be performed with the utmost protection of the intestine

- Mobilization of right hemicolon (Cattell/Braasch – maneuver)
- Kocher – maneuver
- Exposure of abdominal aorta and inferior caval vein from bifurcation up to superior mesenteric artery
- Broad mobilization of the ligament of Treitz and distal duodenum
- Transection of inferior mesenteric artery
- Transection of inferior mesenteric vein
- SMA is encircled
- Aorta and IVC are encircled twice distally
- Division of gastrocolic omentum
- Mobilization of left colon
- Dissection of complete colon and exposure of colic vessels
- Antegrade decompression of the intestine as proposed by some centers is discouraged because of mechanical stress
- Complete colectomy (or left hemicolectomy if right hemicolon is procured) after transection of terminal ileum/sigmoid to expose mesentery root
- Medial visceral rotation and mobilization of pancreatic tail/spleen
- Division of highest jejunal arcades close to jejunal wall
- Transection of proximal jejunum 5–10 cm post Treitz with linear stapler
- Anterior exposure of superior mesenteric vessels by transverse dissection of the mesenteric root distal to the level of the middle colic vessels

In the case of simultaneous pancreas procurement, inferior pancreatoduodenal vessels have to be respected. Very early branching of the SMA may be a contraindication for simultaneous procurement in rare cases and procurement of the intestine should be preferred. However, when complex anatomical situations present, en-bloc procurement with subsequent back table separation should be performed. The latter procedure shortens the donor procedure but prolongs cold ischemia time

- The anterior side of the mesentery root is marked with a suture to avoid rotated implantation
- Transection of postpyloric duodenum with linear stapler
- Ligation of left gastric artery, division of short gastric vessels to the spleen
- Liver graft dissection according to standards
- The abdominal aorta is encircled distal to the diaphragm
- Thoracic organ dissection according to standards
- Prior to cannulation of abdominal aorta administration of 300 IU heparine per kg body weight (at least 3 min before cannulation)
- Cannulation of the inferior mesenteric vein is strongly discouraged

2.3. Perfusion

In accordance with thoracic team, cross-clamping or ligation of abdominal aorta in the subdiaphragmal portion and closure of IVC proximal to the bifurcation to avoid backflow of venous blood from lower extremities are to be performed.

Afterwards flushing with pressure perfusion (150 mmHg) is initiated,

Venous blood is drained via the distal IVC

The intestine is cooled topically with 4 °C cold solution

Caveat: Perfusion of the intestine is limited to approximately 500–1000 ml by manual compression of the SMA to avoid hyperperfusion

Intraluminal perfusion is recommended by some centers, however, data on the benefits are inconsistent.

2.4. Organ retrieval

After flushing of abdominal organs is finished, the intestine is removed as the first abdominal organ after *in-situ* clamping and dissection of the SMA and SMV.

The subpancreatic portions of SMA and VMA are ligated then.

Alternatively, en-bloc removal with pancreas and back table preparation.

2.5. Organ packing

1st bag: organ in perfusion solution (temperature 4 °C)
2nd bag: sterile ice cold Ringer's lactate or saline
3rd bag: nil

Additional iliac vessels may be packed together with the graft or put in an extra bag.

No air or ice in any bag.

A. PASCHER, BERLIN

GUIDELINE FOR MULTIVISCERAL PROCUREMENT

1. Preparation

Before the start of the multivisceral procurement, the following data should be checked and considered as well by the explantation team as well as by the team of the recipient center:

1.1. Patient selection

Cause of death/resuscitation/shock
Cross match
HLA-Matching
Viral status
Laboratory: liver enzymes, cholestasis parameters, lipase, sodium, creatinine, BUN, CRP, WBC, RBC and PLT
Vasopressor therapy
Need for packed red blood cells and fresh frozen plasma
Volume therapy
Duration of ICU-stay
Kidney function
Medical history
Enteral nutrition?

1.2. Donor criteria

Age	≤45 years
Intensive care	≤5 days, enteral nutrition desirable
height/body weight	BMI ≤25 Matching with recipient
Crossmatch	Negative
Cold ischemia	≤6 h
Cause of death/ Medical history	Exclusion criteria: – blunt/sharp abd. trauma with operative procedures, e.g. splenectomy – Asphyxia, CO-intoxication – Resuscitation, long duration of hypotension – Shock–Large blood losses; high amounts of packed RBC – Alcoholism, i.v.-drug abuse – Arteriosclerosis – Diabetes mellitus – History of operative procedures of the small intestine – State after peritonitis – High amounts of vasopressors
Laboratory	Sodium <150–155 mmol/l Caveat: elevated liver enzymes/lipase after trauma No CMV high risk constellation

1.3. Donor preparation

* Brain death protocol
* Informed consent
* Steroid premedication
* Crossmatch
* Examination of the skin
* Rectal digital examination

2. Procurement technique

(Multivisceral Transplant)

2.1. Preliminary remark

Simultaneous intestine/pancreas procurement should be performed by the center performing the intestinal transplant;

Laparotomy should commence in presence of the intestinal team.

2.2. Operative procedure

- Median laparotomy and sternotomy from jugulum to symphysis
- In case of ascites:
  Asservation of ascites (microbiology, cytology and biochemistry)
- Insertion of thoracic retractor

- Separation of Ligg. teres hepatis and falciforme

Judgement of small intestine

- General state of organ (edema, congestion and hematoma)
- Motility
- Adhesions and peritonitis
- Angiodysplasias, petechial bleeding and signs of contusion

At this point start of recipient operation in the case of a negative crossmatch

- Dissection of adhesions of colon/spleen to the parietal peritoneum
- Abdominal retractor system
- Exploration of abdomen and exclusion of any organ pathologies

Caveat: further operative steps should be performed under utmost protection of the intestine

- Mobilization of right hemicolon (Cattell/Braasch – maneuver)
- Kocher – maneuver
- Exposure of abdominal aorta and inferior caval vein from bifurcation up to superior mesenteric artery
- Broad mobilization of the ligament of Treitz and distal duodenum
- Transection of inferior mesenteric artery
- Transection of inferior mesenteric vein
- SMA is encircled
- Aorta and IVC are encircled twice distally
- Division of gastrocolic omentum
- Mobilization of left colon
- Dissection of complete colon and exposure of colic vessels
- Antegrade decompression of the intestine as proposed by some centers is discouraged because of mechanical stress
- Complete colectomy (or left hemicolectomy if right hemicolon is procured) after transection of terminal ileum/sigmoid to expose mesentery root
- Medial visceral rotation and mobilization of pancreatic tail/spleen
- Mobilization of left liver lobe up to the left liver vein
- Transection of minor omentum under protection of accessory left hepatic artery
- Division of gastrolienal ligament and encircling of distal esophagous
- Transection of the cardia with linear stapler
- The abdominal aorta is encircled distal to the diaphragm
- Thoracic organ dissection according to standards
- Prior to cannulation of abdominal aorta administration of 300 IU heparine per kg body weight (at least 3 min before cannulation)

2.3. Perfusion

In accordance with the thoracic team, cross-clamping or ligation of abdominal aorta in the subdiaphragmal portion. Closure of IVC proximal to the bifurcation to avoid backflow of venous blood from lower extremities.

Afterwards Flushing with pressure perfusion (150 mmHg) is initiated

Venous blood is drained via distal IVC

Topical cooling is initiated with 4 °C cold solution

Caveat: Perfusion of the intestine is limited to approximately 500–1000 ml by manual compression of the SMA to avoid hyperperfusion

Intraluminal perfusion is recommended by some centers; however, data on the benefits are inconsistent.

2.4. Organ retrieval

En-bloc removal after the thoracic organs has been retrieved.

2.5. Organ packing

1st bag: organ in perfusion solution (temperature 4 °C)
2nd bag: sterile ice cold Ringer's lactate or saline
3rd bag: nil

Additional iliac vessels may be put in an extra bag or included in the 1st bag.

No air or ice in any bag.

St. BROSE, DRESDEN

GUIDELINE FOR HEART PROCUREMENT

1. Preparation

Before the start of the heart procurement, the following data should be checked and considered by the explantation team as well as by the team of the recipient center:

1.1. Check list

- Death certificate
- Protocols of brain death
- Informed Consent
- Blood Group
- Virus serology
- Laboratory findings (CK, CK-MB, Troponin and blood gas analysis)
- Anamnesis
- Echocardiography, chest X-Ray, coronary angiogram (if available)
- Medication during ICU-Course (esp. catecholamines etc.)

1.2. General comments for donor selection

- Donor height and weight
- Donor age
- Mode of death, course until organ donation (Resuscitation?)
- Potential ischemic time
- Requirements and dose of catecholamines
- ECG (AFib, bundle or AV Blocks and signs of Hypertrophy)
- Echocardiography (Heartsize, wall motion disturbances, hypertrophy, valve abnormalities, LV-Function and RV-Function)
- Coronary angiogram (no relevant stenosis)
- Serology (HIV, HCV, HbsAg neg and CMV)
- Laboratory findings (Troponin low, Na <150 mmol/l, pH normal)
- Final Assessment by the surgeon in the OR (Inspection, Palpation)

1.3. Unsuitable or marginal donors

- Size mismatch >10–20%, Donor ♀ – Recipient ♂
- Donor age >50 years
- ECG: signs of infarction, hypertrophy and atrial fibrillation
- Echocardiography: wall motion disturbances, valve abnormalities, septum hypertrophy (>12 mm) and heart enlargement
- Elevated cardiac enzymes, Na > 150 mmol/l, pH < 7,2
- Coronary angiogram: coronary artery disease
- History of resuscitation, history of hypotension, history of ventricular fibrillation
- High dose of catecholamines (Dopamin >6 μg/kg/min, need for epinephrin or norepinephrin)
- HBs-AG positive, HIV positive and Anti-HCV positive
- Untreated Sepsis and Aspergillose
- Cancer with metastasis (esp. Mamma-Ca, Bronchial-Ca and Melanoma)
- Cause of death (hanging, strangulation, drowning, electric shock, CO-intoxication and gunshot wound head)

Blood sampling from the donor for postoperative actual crossmatch.

1.4. Patients position on the operation table

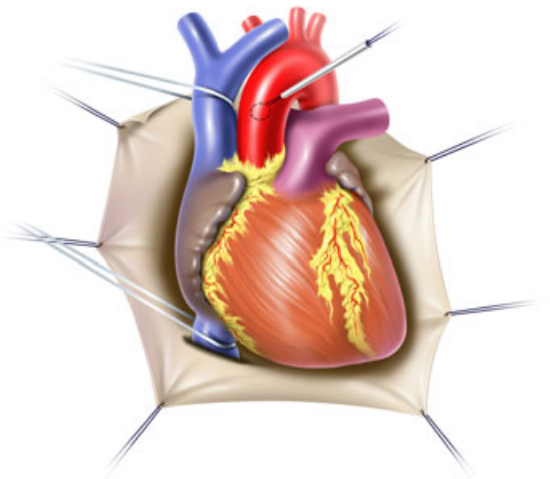
- Slightly overstretched in supine position
- Arms spread
- Head reclined
- Shaving from Jugulum to the pubis
- Disinfection and sterile drape

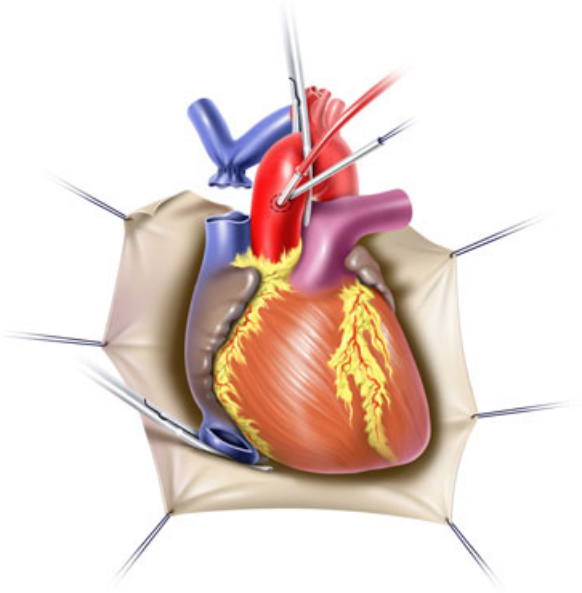
2. Procurement technique

2.1. Operative technique

- Standard median sternotomy with Accu-saw, oscillating saw or sternum bit (can be performed by the abdominal team)

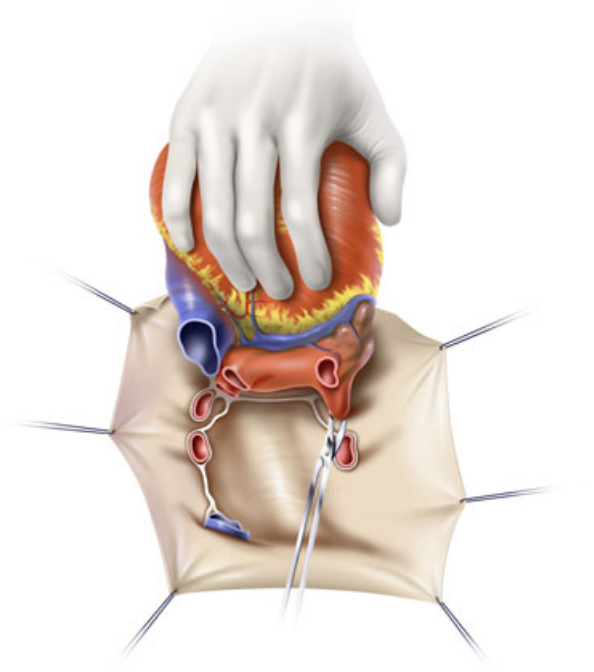
- Dissection thymus
- Opening of the pericardium and exposure of the great vessels (Aorta until aortic arch eventually with origin of the supraaortal branches, pulmonary artery)
- Fixation of the Pericardium with sutures
- Dissection around the superior V. cava (SVC) and also inferior V. cava (IVC) and put two ligatures around the SVC
- Separation of aorta and pulmonary artery
- Purse string suture at the ascending aorta for perfusion cannula





- Position the perfusion cannula (aortic needle vent) and connect to the cardioplegia line after careful de-airing
- Optionally invasive pressure measurement related to the center protocol (aorta, left atrium, central venous pressure and pulmonary artery)
- Application of at least 25.000IE Heparin i.v. (300 units/kg)
- Optionally, intravenous administration of prostaglandins (for example 100 µg Iloprost or 250 µg Flolan) via central venous line related to the center protocol and in consensus with lung team and abdominal team
- Inflow-Occlusion with double ligation SVC (ask Anesthesiologist to remove all central venous line before), occasionally clamp the IVC
- In close coordination with the abdominal team cross-clamping of the ascending aorta as close to the arch as possible for maximum length of the aorta at the donor heart
- Incision of the (clamped) inferior vena cava (agreement with abdominal team) (CAVE! Stay supradiaphragmal!!!)
- Incision of the left or right upper pulmonary vein (if the heart is taken only), respectively, the left atrial appendage (if combined heart and lung retrievement) and if necessary of the main trunk of the pulmonary artery (in case of retrograde lung conservation)
- Let the heart beat empty (support with manual compression) and then start Single-Flush-Heart conservation with 3–4l Bretschneider HTK-Solution over at least 10 min related to the particular regimen of the center, either with gravity or with pressure, equivalent 1000 ml UW (+16 mg Fortecortin and 40 IE Insulin) with a special infusion system (brought by the heart team)
- *Accepted storage and conservation solutions:* HTK-Bretschneider, UW, Celsior
- At this time abdominal perfusion is also started and can cause flooding into the pericardium, which should be dealt with strong suction devices
- Local cooling in the pericardial cavity with cool/cold water but no ice
- Observe adequate filling of the aorta indicating that the aortic valve is competent and to avoid left ventricular distension, observe how fast electrical activity disappears. Continuing electrical activity may indicate unknown coronary artery disease or left ventricular hypertrophy (in this case more and longer administration of cardioplegia may be necessary)
- After cardioplegia removal of the perfusion cannula, knotting of the purse string suture

- Division of IVC and SVC (between the two ligations to avoid excessive bleeding and an unclear situs) as well as the pulmonary veins on both sides if the heart is taken alone. If heart and lungs are both taken transverse incision of the left atrium and resection leaving a sufficient cuff of the left atrium around the orifices of the pulmonary veins



- Release the left atrium from the posterior mediastinum by separation from the posterior pericardium until the pulmonary arteries are shown
- Dissection of aorta and pulmonary artery should be as long as possible, pulmonary artery in agreement with lung team, if possible on the level of bifurcation
- Retrieval of the organ out of situs, *Now repeat final inspection!*
- Storage in sterile bag (3-bag method), in the first bag heart with cold perfusion solution, in the two outer bags ice water
- Transportation of the bags embedded in crush-ice in a cooler-box

2.2. Postprocurement care of donor

1. Removal of all foreign materials and residual fluid
2. Wound closure with solide sutures (meticulous and watertight)
3. Neat skin closure
4. Wound dressing
5. Removal of all underlying derivations
6. Dignified and respectful transfer of the cadaver

C. BINNER, H. BITTNER, LEIPZIG

GUIDELINE FOR LUNG PROCUREMENT

1. Preparation

1.1. Members of the thoracic procurement team

The donor procurement team for Lung transplantation (Ltx) usually consists of a specially trained cardiac or thoracic surgeon who is certified in performing cardiothoracic donor operations. Additional to the responsible surgeon, a trainee donor surgeon and a donor perfusionist or technician completes the team.

1.2. Equipment

For avoiding costs and displeasure, the procurement team bring their own equipments to the donor hospital such as:

- flexible adult bronchoscope
- auto-suture (TA 30)
- special drugs e.g. prostaglandins E 1, surfactant
- cool box with perfusion fluids (6 l of Perfadex)
- organ storage bags
- ice
- ante- and retrograde perfusion cannula or catheters
- extra invasive monitoring material (e.g. Swan Ganz Catheter, left atrial pressure line)

1.3. Transportation

Good organization and arrangement of transportation facilities (car, aircraft and helicopter) is the key of success for low ischemic time. It is advisable for the procurement team to bring personal ID or passport even in EU region to avoid problems with customs officers. Be aware of sudden weather changes especially in winter time, rush hour or longer preparation time in redo surgery for the implantation team in the recipient hospital. It is an indispensable pre-condition that after organ explantation separate transportation for the thoracic team is necessary.

Communication with the local coordinator and other explantation teams on one side and the transplant surgeon in the recipient hospital on the other side is essential for a perfect run and an ischemic time as short as possible.

1.4. Responsibilities for the thoracic team and general assessment

After arrival at the donor hospital the team should introduce him/herself to the local transplant co-ordinator, other transplant teams and nursing staff. Donor charts must be checked for:

- consent of donation
- certification of (brain) death
- blood group and compatibility
- serological and microbiological results
- risk factors with suitability of the donor (e.g. malignancies, pulmonary diseases and history of death)

The thorax team should also review

- X-ray or CT-scan (no infiltrate)
- ECG and hemodynamic monitoring
- blood gases with FiO_2 1.0 ($pO_2 > 300$ mmHg) and 0.21 ($pO_2 > 100$ mmHg)
- ventilation parameters (e.g. PEEP) and lung compliance
- blood loss and replacement (colloidal, crystalloid and blood products)
- administration of drugs (inotropes, antibiotics and prednisolone)
- blood results
- former bronchoscopic findings

A bronchoscopy should be performed by the surgeon to asses the quality of the lungs (inflammation, edema, laceration, sputum consistence and amount). If possible a sputum sample is obtained, and if necessary a bronchial lavage performed. Suspect findings must be communicated and discussed with the responsible surgeon in the recipient transplant center because this comprehensive review will form the essential basis for acceptance or denial of the organs.

1.5. General assessment of thoracic organs

In most cases, opening of the chest is done by the abdominal team via median longitudinal sternotomy

with a saw or hammer and chisel. For sternotomy, lungs should be disconnected from ventilation to avoid violation. The abdominal team is first, preparing the abdominal situs (liver, kidney and pancreas). This can be time consuming depending on the visceral findings. Therefore, good organisation is necessary, clearly stating when the thoracic team can come to the operating table to begin. The pericardium and pleura should be opened by either the cardiac or thoracic surgeon. If the heart is also going to be explanted, the cardiac surgeon examines the heart for:

- contractility
- size
- coronary artery sclerosis
- signs of valvular diseases (aortic stenosis and mitral insufficiency)
- anomalies (like persistent left vena cava superior)

During this period, the anaesthesiologist must have a look for hemodynamic changes and rhythm disorders to avoid instability and need for resuscitation. After examination of the heart, the retrieving thoracic surgeon is going to examine both lungs for:

- size and appearance
- atelectasis, injuries and consolidation
- bullae and oedematous swelling
- palpation for any suspect tumor
- adhesions
- air leakage

For good visualization, the right and left lung must be luxated. Therefore, it is again extremely important to communicate with the responsible anaesthesiologist to avoid hemodynamic instability. If necessary, a blood sample for blood gas analysis can be drawn separately from both sides of pulmonary veins.

1.6. Communication

The explant surgeon must contact the responsible surgeon in the recipient hospital and discuss any suspect findings. If the lungs are accepted, time management is very important to keep ischemic time as short as possible, especially when special arrangements at the recipient hospital have to be performed (crossmatch results), or difficult and time consuming procedures are expected in redo surgery. Ensure that transportation facilities (e.g. helicopter and aircraft) are still available. The interaction for cooperation and coordination with the whole explantation team (scrub nurse, heart surgeon, abdominal surgeon and anesthesiologist) in the donor hospital is required at this time. Tell the anesthesiologist that a central venous line must be removed after administering heparin. Let them know that lung ventilation must be continued also when the heart is explanted. Correspond with the scrub nurse and make sure that all instruments and materials you need are ready and handy.

2. Procurement technique

2.1. Heart and lung preparation and perfusion

Main pulmonary artery should be separated from ascending aorta and mobilized carefully. It is appropriate to dissect superior vena cava (SVC) from right pulmonary artery and embrace proximally the vein with a suture line. In correspondence with the abdominal and heart surgeon, the anesthesiologist administers heparin (300 IU/kg). Cannulation for abdominal perfusion can now be performed. Aortic and pulmonary artery cannula can be positioned and connected to the cardioplegia and pulmoplegia perfusion after de-airing the lines.

All central venous lines have to be removed now and ventilation continued with FiO_2 0.5. With the embraced suture line around the vena cava superior, the vessel is ligated to stop cardiac inflow. Incise inferior vena cava (IVC) right above the diaphragm. Do not incise the inferior vena cava under the diaphragma. For liver transplantation, it is helpful to have enough material for SVC anastomosis. Open the left atrial appendage, if heart is harvested or left atrium if not to decompress left ventricle. Cross clamp the ascending aorta as distal as possible. Cold ischemia time begins at this moment. Cardioplegic solution can be started now. If no left ventricular distension happens, pulmonary perfusion can start. Always remember: cardiac decompression and cardioplegic solution first, then pulmoplegia! Continue heart and lung perfusion until recommended volume is reached. Always look for left ventricular distension. Surface cooling with cold water (no ice cubes) is admitted. The abdominal team usually starts perfusion when ascending aorta is cross clamped. Effluent perfusion solution is removed by strong suction from intra-abdominal and thoracic parts. After finishing the cardio- and pulmoplegia, both cannulas can be removed.

2.2. Heart dissection (see guideline for heart procurement)

Heart explantation is performed first by dividing the IVC. In correspondence with the heart surgeon, left and right pulmonary veins are divided from left atrium, leaving a sufficient muscular cuff around the ostia of the pulmonary veins. The left atrial cuff is essential for an uncomplicated anastomosis with the lung recipient and has absolute priority. Left atrium is released from the dorsal part of the mediastinum by separating it until complete exposure of both sides of pulmonary arteries. Divide

ligated SVC near the confluence of the azygos vein. On the bifurcational level, the pulmonary artery is divided to leave enough main pulmonary artery for the heart team, especially in heart recipients with biventricular assist devices or congenital abnormalities. At the end of the heart explantation, the aorta is divided as high as possible depending on the heart recipient situs. In patients with complex congenital malformations or left ventricular assist devices for example, an aortic arch is often required and therefore all brachiocephalic arteries must also be divided.

2.3. Lung dissection

After the heart has been explanted as described earlier, lungs can now be dissected. Ventilation can be interrupted and pleura opened widely on both sides. Along the phrenic nerve, the anterior part of the pericardium is removed anterior to the pulmonary hilum and the posterior layer of the pericardium excised transversely. It is opportune to start lung dissection by dividing the inferior pulmonary ligament on the left side first. Exposing the left lung by luxating on the right side, it is possible to go upwards close to the esophagus and transect the descending aorta below the origin of the left subclavian artery. After repositioning the left lung in the left thoracic cavity, the dissection of the right lung can be started by dividing the inferior pulmonary ligament, luxating the right lung to the left and going upwards close to the esophagus to the level of the azygos vein. Relapse the right lung into the right thoracic cavity and divide all neck vessels away from trachea. Mobilize gently to avoid disturbance to the membranous part of the trachea. Ask the anesthesiologist to inflate lungs manually until all atelectases (typically located on the posterior part of both lower lobes) are visually opened. When all atelectases are removed sufficiently, inflation should be held at a mid ventilatory level, before stapling the trachea as high as possible with an auto-suture stapler (e.g. TA 30) to ensure that the endotracheal tube has been retired carefully. The ventilation can be stopped after placing the first stapler line. Place a second and third stapler line and divide the trachea between the proximal and mid line. Disinfect the tracheal stump before removing the lung.

2.4. Heart-lung bloc dissection

The perfusion for en-bloc heart-lung explantation is the same as described above for heart and lung. For bicaval insertion technique, it is mandatory to dissect the SVC as high as possible near the confluens of the azygos vein. The posterior layer of the pericardium is excised transversly. Lung dissection starts by dividing the left inferior pulmonary ligament continued by going upwards close to the esophagus until the descending part of the aorta can be transacted below the left subclavian artery. Right lung dissection begins with dividing the right inferior pulmonary ligament and than also going upwards close to the esophagus to the level of azygos vein. Preparation and mobilization of trachea is the same as described before. After an inflation manouver for opening of atelectases, the trachea is stapled with three staple lines and divided in between. The heart-lung bloc can be lifted out of the thorax.

2.5. Back table preparation and package

On a back table, the explanted lungs must be checked for any conspicuous findings (e.g. exorbitant hemorrhage after heparinization, air lekage and iatrogenic trauma). Ensure that every part is complete and has enough material (e.g. atrial cuff). Especially in donors with a longer hospitalization before explantation and a risk for lung embolization, it is advisable to flush the pulmonary arteries retrograde with pulmoplegic solution by inserting a urine catheter in each pulmonary vein orifice and remove thrombembolic material. It is important not to skeletonize main stem bronchus, as this avoids devascularization and lowers the risk for insufficiency of the bronchus anastomosis. Only in case of transplantation of the left and right lungs in different recipient hospitals, the left and right bronchi have to be dissected as near as possible to the carina with an additional stapler line.

For cool conservation and safe transportation, the lungs should be placed in a three bag technique. The inner bag is filled with cooled pulmoplegic solution. The remaining two bags have to be filled with cool 0.9% saline and crush ice. The packed organ is placed in an ice box containing a sample of donor blood and/or spleen for retrospective crossmatch.

3. Leaving the donor hospital

Before leaving the donor hospital, the thoracic team must pack all equipment quietly and efficiently while the abdominal team is still working. The co-ordinator in the donor hospital has to be asked for necessary paper work, and a short concise note is made for the donor's medical notes. The thoracic surgeon should express his final thanks to all members of the donor hospital and the transplant teams. As soon as possible, the return journey must start and the responsible surgeon in the recipient hospital is to be informed about the explantation, organ procurement and estimated arrival time.