

ANAESTHETIC PROTOCOL FOR LIVER TRANSPLANTATION

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Scotland

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CONTENTS

INTRODUCTION	3
PRE-OPERATIVE ASSESSMENT	4
MANAGEMENT OF THE ANAESTHETIC	5
ACCESS LINES	6
MONITORING	7
OTHER PATIENT MANAGEMENT	8
INFECTION CONTROL	9
MONITORING OF RENAL FUNCTION	9
MANAGEMENT OF BLOOD LOSS AND COAGULOPATHY	10
MANAGEMENT OF BIOCHEMICAL ABNORMALITIES	11
VENO-VENOUS BYPASS	12
REPERFUSION	12
TRANSPORT TO ITU	12
RESEARCH	12
 Appendix 1	
Investigations on elective patient readmitted for transplant	13
 Appendix 2	
Investigations on patients with fulminant hepatic failure	14

INTRODUCTION

This protocol takes account of our experience of liver transplantation in Edinburgh from November 1992. It is revised annually to accommodate the preferences of different consultants and reflect our increasing experience and change in practice.

Anaesthetic Staffing

Nine consultant anaesthetists participate in the liver transplant programme (Drs Alistair Lee, David Cameron, Rory Mayes, Craig Beattie, Euan Thompson, Helen Usher, Mort Kelleher, Oliver Robinson and Philip Docherty.). They work a 1 in 7 rota covering the requirements of the liver, renal and pancreatic transplant programmes in addition to a general Intensive Care (Drs Lee, Cameron and Robinson) commitment and theatre sessions predominantly related to hepatobiliary work. Middle grade cover for transplantation/transplant HDU (Ward215) comes from ward 118 (ICU) and those attached to theatres 15 and 16.

Location

All hepatobiliary surgery, including transplantation, is undertaken in Theatre 15 and 16. Patients requiring ventilation are managed in Ward 118 Intensive Care Unit. Ward 215 is the transplant High Dependency Unit. The consultant anaesthetists will assist with the management of patients in all the above areas and will have, along with other Intensive Care Consultants, joint responsibility for liver transplant patients in ward 118. They are the contact point for patients in Ward 118.

Timing of Transplantation

Out of hours transplant activity has increased significantly in recent years and is scheduled with consultation between the anaesthetist, surgeon and transplant co-ordinator.

Visitors

Visitors interested in the Anaesthetic or Intensive Care aspects of the programme or wish to arrange a visit should contact Dr David Cameron in the first instance.

PRE-OPERATIVE ASSESSMENT

A detailed assessment will have been made prior to the patient being placed on the transplant list. In those patients where there has been a significant delay between listing and a liver becoming available attention should be paid to any further deterioration in clinical condition with particular emphasis on cardiovascular and respiratory system function.

Waiting list patients will have undergone a formal work-up process, been discussed at a multi disciplinary Friday afternoon meeting and had an additional investigative procedures considered necessary before placing on the transplant waiting list. Details of the patients on the waiting list together with their most recent results are available at all times.

Routine investigations

See preoperative assessment protocol for those investigations performed prior to inclusion on the transplant waiting list.

Appendix 1 lists investigations that should be carried out when a waiting list patient arrives for transplantation.

Appendix 2 lists investigations appropriate for the patient in fulminant hepatic failure awaiting transplantation.

Waiting list patients will be seen by a consultant anaesthetist during their formal assessment to discuss the procedures involved during the anaesthetic and early post operative period. The patient may visit Ward 118 and be introduced to one or more of the senior nurses thus helping to reduce patient and relatives anxiety.

MANAGEMENT OF THE ANAESTHETIC

Premedication

Premedication for anxiolysis will not be given routinely, but if required will consist of an oral benzodiazepine (Temazepam) 1 – 2 hours preoperatively.

Patients not on a proton pump inhibitor should be prescribed the H₂ antagonist ranitidine (150 mg orally or 50 mg IV). For maximum effectiveness it must be prescribed the night before and the morning of surgery.

PREPARATIONS BEFORE INDUCTION

Monitoring and invasive access lines

In haemodynamically stable waiting list patients an intravenous cannula will be inserted in the anaesthetic room and the patient monitored non-invasively (5 lead ECG with ST analysis, pulse oximeter and non-invasive BP cuff) prior to the intravenous induction of anaesthesia. All other lines will be inserted post induction. An arterial line may be inserted under local anaesthesia prior to induction if there are preoperative concerns about the potential for haemodynamic instability,

Emergency drugs

10 ml syringes of epinephrine 1:100 000 and 1:10 000 are drawn up preoperatively.

Blood products

If blood products have been ordered by the anaesthetist their arrival along with the RCC should be checked by the ODP prior to surgery commencing.

4 units of FFP may be pre thawed and stored in BTS at anaesthetist's request.

ANAESTHETIC INDUCTION

Patients inadequately fasted, or otherwise at risk of regurgitation and aspiration, will be anaesthetised following preoxygenation with a facemask, using a rapid sequence technique. Propofol 1-2.5 mg/kg followed by suxamethonium 1 mg/kg or Rocuronium 0.6 mg/kg are administered and cricoid pressure applied.

Fasted patients may be induced with propofol alfentanil (0.25 – 1.0 mg) and paralysis achieved with atracurium (0.6 mg/kg) or other NMBA.

A high volume, low pressure endotracheal tube is used in case the patient is not able to be extubated in the early post operative period.

MAINTENANCE OF ANAESTHESIA

A continuous infusion of alfentanil +/- midazolam is started after induction (alfentanil 20 mg (40 mls) +/- midazolam 20 mg (10 mls) at a rate of 4-6 mls/hr.

Muscle relaxation is maintained with a continuous infusion of atracurium (40 – 60 mg/hr, 10 mg/ml).

Isoflurane 0.5 – 1.5% is the volatile agent of choice. An oxygen–air mix is used as the carrier gas to avoid the problems of bowel distension and marrow suppression associated with the prolonged exposure to nitrous oxide.

Ventilation is controlled to an end tidal PaCO_2 of 4-4.5 kPa. Greater degrees of hyperventilation may be indicated to aid in the control of intracranial pressure in patients with fulminant hepatic failure. A “within circle” PEEP value is available and may be indicated if oxygenation is a problem.

ACCESS LINES

All lines will be inserted aseptically.

- | | | |
|----|------------------------------|---|
| 1. | Right internal jugular vein. | a. Quad lumen central line
b. Edward Life Sciences 7.5Fr pulmonary artery catheter c.
Arrow MAC 2 lumen central venous catheter |
| 2. | Left radial artery | 3Fr arterial line for blood sampling. |
| 3. | Right femoral artery | 4Fr Vygon arterial line for uninterrupted monitoring of BP. |

With the present surgical technique of ‘piggy-back’ +/- creation of a Portal V-IVC shunt to decompress the gut veno-veno bypass is not required. In the rare instances when veno-veno bypass is required percutaneous access to the left internal jugular vein may be required for venous return from the pump.

MONITORING

1. CARDIOVASCULAR SYSTEM

Haemodynamic monitoring consists of ECG (5 lead with ST segment analysis), arterial pressure x 2, central venous pressure and pulmonary artery pressure together with continuous display of arterial (ear lobe pulse oximeter) and mixed venous oxygen saturation and cardiac output. The pulmonary artery catheter will be removed at the end of surgery or upon return to Wd 118 unless the patient's clinical condition merits further monitoring.

2. RESPIRATORY SYSTEM

Ventilatory monitoring consists of airway pressure, inspired and expired oxygen concentration, tidal and minute volume, inspired and end tidal CO₂ (and isoflurane concentration).

3. RENAL FUNCTION

Urine output is measured hourly.

4. TEMPERATURE

Core temperature is continuously measured by the thermistor on the PA catheter.

5. BIOCHEMISTRY

Arterial blood gases, Na⁺, K⁺, ionised Ca²⁺, lactate and glucose are measured presurgery, every 30 minutes following induction, immediately after 1. Clamping of the major veins, 2. The end of the anhepatic phase, 3. Release of the venous clamps, 4. Unclamping of the hepatic artery and hourly until closure. Additional samples as clinically indicated.

6. HAEMATOLOGY AND COAGULATION

Hb and ROTEM analysis is performed presurgery, end of hepatectomy, 10 mins post reperfusion, 60 minutes post reperfusion, and end of surgery. Additional testing if clinically indicated eg. Excessive surgical bleeding or no clot formation.

A full haematology coagulation screen (PT, APTT, fibrinogen, D-dimers, platelet count) will have been performed pre-operatively but should be repeated peri operatively if significant intra-operative blood loss

For identification and cross checking of blood and products the patient name, hospital number and DOB should be written on his right shoulder or his wrist band stuck to his shoulder.

OTHER PATIENT MANAGEMENT

Pressure Care

The arms are wrapped in Gamgee and placed at the patients side (in preferably the neutral position) in order to reduce the recognised risk of brachial plexus injury.

The eyes are taped closed.

All possible pressure points should be examined carefully before and after draping to reduce the possibility of pressure damage occurring.

All monitoring lines and ECG leads should be positioned carefully to avoid injury and ECG electrodes are sealed down with Tegaderm adhesive dressings.

Temperature Care

This is a priority from the moment the patient arrives in the anaesthetic room

The theatre table mattress should be pre-warmed

The under mattress warmer should be turned on (default 40°C) in the anaesthetic room during induction and line/catheter placement

The under mattress and lower ½ mattress should be reconnected and switched on once the patient is transferred to theatre

Temperature should be monitored continuously during the case

Pre warm ITU bed

If there is significant delay between finishing and transfer to ITU temperature should be monitored and recorded

All intravenous fluids are warmed. A heat and moisture exchanger is used at the patient end of the anaesthetic circuit.

Temp management for fulminant patients may deviate from routine practise and should be discussed

INFECTION CONTROL

A history of drug allergy should be carefully checked to ensure that true drug allergy exists.

Antibiotic prophylaxis is Amoxicillin 1g, Gentamicin 2mg/kg and metronidazole 500mg at induction and amoxicillin 1g and metronidazole 500mg at 8 hours. The first dose should be administered pre-induction and occasionally a second dose will be required towards the end of the operation or immediately upon arrival in ITU.

For patients with penicillin allergy Ciprofloxacin 400 mg + Vancomycin 1 g is prescribed at induction and at 12 hours). Metronidazole is required for patients requiring a roux en y.

Antifungal prophylaxis is Fluconazole 100 mg iv once per day.

Antibiotic prophylaxis is not routinely required for patients returning from theatre with packs in situ

MONITORING OF RENAL FUNCTION

Maintenance of intravascular volume together with a satisfactory mean arterial pressure are the most important renal supportive measures. An adequate urine output relies upon.

1. Maintaining normothermia
2. Aggressive replacement of intravascular fluid losses using appropriately warmed fluids.
3. Maintaining satisfactory MAP

Patients requiring RRT pre-op may require this to be continued intra-op.

MANAGEMENT OF BLOOD LOSS AND COAGULOPATHY

5 units of red cell concentrate (RCC) are routinely supplied by the Blood Bank preoperatively. A minimum of 5 units of blood should be available in theatre at all times. In the case of complex transplants with abnormal vascular anatomy, re-transplants or previous surgery where there is a high possibility of significant blood loss 10 units of RCC should be ordered. Suitability of RCC for electronic release from BTS should be checked. The routine ordering of other blood products (FFP, platelets) is not necessary but FFP may be requested to be pre-thawed.

Prophylaxis against blood loss

1. Maintenance of body temperature.
2. ROTEM analysis at induction of anaesthesia will determine need for blood products pre-surgery
3. Prophylactic use of anti-fibrinolytic agents is no longer used

Treatment of major haemorrhage

1. Prevent/correct hypothermia, acidosis and hypocalcaemia as above.
2. Cell salvage from operative field
3. Transfuse banked red cells where haemoglobin <7g/dl (8g/dl if ischaemic heart disease) or ongoing rapid blood loss
4. Platelet/FFP/Cryoprecipitate transfusion and tranexamic acid administration where indicated by ROTEM algorithm
5. Target FIBTEM is >8mm
5. FFP used as 1st line treatment for Fibrin deficiency.
6. Cryoprecipitate used as 2nd line treatment for Fibrin deficiency
 - where 6 units FFP have been transfused and ROTEM suggests persistent fibrinogen deficiency
 - where CVP >10 and ROTEM suggests persistent fibrinogen deficiency
 - where FIBTEM A10 <5mm
7. Haemostatic interventions not described above (Factor concentrate, recombinant Factor 7) are very rarely used in the SLTU and is at discretion of clinical team.

MANAGEMENT OF BIOCHEMICAL ABNORMALITIES

Hypocalcaemia

Sufficient calcium in the form of an intravenous infusion of calcium chloride must be given to avoid hypotension (approx 5 – 10 ml/litre of blood products) depending on the severity of liver dysfunction. This is best administered by a slow continuous infusion at a rate of 2-20 ml/hr during periods of continuous blood loss. Ionised Ca^{++} can be monitored from ABG samples. Patients frequently require an infusion of calcium to avoid hypocalcaemia.

Metabolic Acidosis

Metabolic acidosis may be due to poor tissue perfusion and every effort should be made to optimise the circulation. Any deterioration during the anhepatic phase should rapidly improve with a satisfactory functioning graft and is a useful indicator of early graft function. Increasing acidosis after reperfusion is often the result of acidic products from the ischaemic liver being flushed into the circulation. This resolves spontaneously over a few hours without specific treatment. However, increasing acidosis associated with hyperlactataemia post reperfusion may be an early indicator of poor graft function. In the absence of hyperlactataemia or poor tissue perfusion, infusion of a large volume of chloride based solutions may cause metabolic acidosis.

A base deficit in excess of 10 mmol/l would be a level at which treatment should be considered.

Partial correction with 50 ml boluses of 8.4% NaHCO_3 whilst monitoring acid base status with regular ABGs would be appropriate.

Hyperkalaemia

Transient hyperkalaemia occurs on reperfusion of the new liver, but it is short lasting and usually no specific treatment is required. The patient should have normal ionised calcium levels before the clamps are removed and reperfusion occurs. If hyperkalaemia is present prior to clamp release, glucose and insulin should be given at this stage.

Hypokalemia

Potassium supplementation may be required once the new liver starts to function.

Hypo- and Hyperglycaemia

Hyperglycaemia may develop as the operation progresses, but does not usually require treatment. This is partly due to the glucose content of bank blood.

Patients with fulminant hepatic failure will often require a continuous infusion of 50% dextrose in order to avoid hypoglycaemia.

VENO-VENOUS BYPASS

With the introduction of the piggyback technique cross clamping of the IVC does not occur and veno-venous bypass is not required. When indicated, surgically placed portal- and femoral-venous cannulae drain blood which passes through a centrifugal pump before being returned to the patient. In these circumstances it will be necessary for the anaesthetist to insert 2 Arrow 8.5 Fr percutaneous sheaths (usually into the left neck) Pressure is measured continuously on the downstream side of the pump proximal to the return cannulae. A flow of 1.6 l/min with a line pressure <250 mmHg and pump revs of <200/min is achievable and the system should be reviewed if these values are not met.

REPERFUSION

The biochemical abnormalities described above should be addressed, but it is common even with normal biochemistry for a degree of hypotension to develop in the early reperfusion phase. This is usually associated with an increased cardiac output providing ionised calcium concentration is maintained and is best managed with small increments of a vasoconstrictor or inotrope eg. 1:100 000 epinephrine. On occasion a more prolonged administration may be required and an infusion of epinephrine or nor-epinephrine may be appropriate.

DOCUMENTATION

A large amount of information is generated during the procedure. In addition to anaesthetic record completion of anaesthetic audit sheet is essential.

TRANSPORT TO ITU

This should only take place when it is certain that the patient is not bleeding and is otherwise stable. A full biochemical and coagulation profile should be carried out in theatre before transfer. The patient is transferred onto an ITU bed in theatre. ECG, SaO₂, ET-CO₂ and intra-arterial BP is monitored during transfer to ITU. Intracranial pressure can also be monitored if appropriate. ITU should be warned in advance of patient arrival.

A written summary should be written in the patients notes upon arrival in ICU and a formal handover to a senior ICU doctor is required.

RESEARCH

Research is an important component of the liver transplant programme and may lead to modification of the standard anaesthetic protocol depending on the study being undertaken.

Appendix 1

Investigations on elective patient readmitted for transplant

Haematology

Hb:
WBC:
Platelets:
PT:
APTT:
Fib:

Clinical Chemistry

Na:
K:
Urea:
Creat:
Glucose:
Bili:
ALT:
GGT:
Alk Phos:
Albumin

CXR: only if new chest signs or no X-ray in last 3 months

ECG:

Additional investigations will depend upon the clinical indications in individual patients:

Appendix 2

Investigations on patients with fulminant hepatic failure

Haematology

Hb:
WBC:
Platelets:
PT:
APTT:
Fib:

Clinical Chemistry

Na:
K:
Urea:
Creat:
Glucose:
Lactate:
Bili:
ALT:
GGT:
Alk Phos:
Albumin:

ABGs

H+:
PaCO₂:
SBC:
BE:
PaO₂
F_IO₂

CXR comments:

ECG comments:

PA cath data

CVP:
RAP:
RVP:
PAP:
PAOP:
CO:
SvO₂:
PvO₂:

Height:

Weight:

ABO group:

CMV status:

Hep A:

Hep B:

HIV:

Hep C:

Intercurrent disease: