Protocol - Aortic and aneurysmal

The safe use of spinal drains in thoracic aortic surgery

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Abstract

Paraplegia is a devastating complication which may occur following surgery on the thoracic aorta. The use of a cerebrospinal fluid drain (CSFD) has helped reduce the incidence of neurological deficit; however, the management of patients with a CSFD postsurgery requires nurses and doctors to have expertise and awareness of the associated complications. The National Patient Safety Agency (UK) has highlighted a number of cases involving inadvertent spinal injections throughout the UK National Health Service (NHS). To this end we have introduced a protocol or ‘care bundle’ for safe CSFD care as well as drain management. The protocol was developed by medical and nursing staff at our institution based on clinical experience and literature reviews over a two-year period (2008–2010). Interventions undertaken during the development of the protocol included discussion with the UK National Patient Safety Agency (NPSA). Content of the protocol was reviewed by internal regulatory bodies within the hospital prior to ratification and general dissemination. Clear guidance is given within the policy on the standards expected when caring for the line and managing drainage according to agreed parameters of spinal cord perfusion pressure. The protocol constitutes five documents which guide staff in the care of CSFD, its routine management, documentation and interventions necessary once neurological deficit is detected. Document 1 which is a checklist, communication tool and aide-memoire was developed to ensure effective management, when the patient arrives in intensive care unit (ICU) from theatre. Document 2 ensures that early detection of a neurological deficit is noted and with Document 3 is acted upon immediately to reverse the injury. Document 4 provides information on the safe administration of analgesia via the spinal drain and has reference to the Glasgow Coma Scale. Document 5 is a bespoke observation chart for documenting CSFD pressure and cerebrospinal fluid drainage. In conclusion, the protocol acts as a guide for safe management of the CSFD and directs staff in reacting to detection of neurological deficit.

Keywords: Spinal; Drain; Paraplegia; Thoracic; Aortic

1. Introduction

Paraplegia is a recognised and devastating complication of thoracic aortic surgery. Significant progress has occurred over the last decade in developing methods to reduce this risk. These methods principally include manipulation of spinal cord perfusion pressure with CSF drainage [1, 2] and distal perfusion [3]. Other adjuncts include: sequential clamping/duration of cross clamp, intercostal reattachment, hypothermia and spinal cord monitoring [4–7]. Lumbar spinal drain insertion and manipulation of spinal cord perfusion pressure is becoming a standard of care in perioperative management of patients undergoing thoracic aortic intervention. However, cannulation of the sub-arachnoid space is not without risks including: meningitis, fistulation, epidural haematoma, and even subarachnoid hemorrhage (SAH) [1, 2]. Although much has been written about outcomes from use of a spinal drain, little if anything has been published about practical issues in managing a spinal drain in the perioperative period in thoracic aortic surgery, or its safe and effective use by medical staff. The Thoracic Aortic Aneurysm Service at Liverpool Heart and Chest Hospital has been developing a programme for intervention on the descending thoracic aorta over the last decade. Our initial experience with the postoperative complication of paraplegia suggested a significant proportion were not acquired intraoperatively but were delayed (POD 1–3) and were often related to deviation from agreed postoperative instructions for management of spinal cord perfusion pressure. We therefore established several protocols (‘paraplegia care bundles’) and audit processes to ensure safe and efficient management of spinal drains as well as ensure compliance with agreed postoperative orders. This manuscript documents our institutional processes and protocols in the spirit of sharing experience and eliminating the ‘learning curve’ for others.

2. Methods and protocols

2.1. Roles and responsibilities

The protocol described in this manuscript is available to all medical and nursing staff working within the Liverpool...
reduce the risk large red labels are attached next to all
ports associated with the spinal drain warning staff not to use for injection (Fig. 1). Once the CSF drain is inserted it is attached to a three-way tap that allows connection directly to a pressure transducer (Fig. 2) for monitoring via one limb of the three-way tap and to a sterile drainage system via the other limb. The three-way tap is kept routed so that the spinal drain is connected to the pressure transducer. In this position there will be no drainage of CSF, and the patient’s position is not critical to the management of the drain.

The National Patient Safety Agency (NPSA) was contacted and asked if they recommended that manometer tubing be colour coded. They stated that at present there are no recommendations. It was therefore decided by the hospital it would use an individual white manometer tube that is separate from all other manometer lines. Due to inadvertent spinal injections throughout the NHS, manufacturers have been tasked by the NPSA with providing dedicated/unique equipment by 2011. To reduce the risk large red labels are attached next to all

### 2.2. Spinal drain insertion

Appropriate consent is taken from the patient and baseline measurements of neurology and coagulation are documented. Only consultant anaesthetists insert a cerebrospinal fluid drain (CSFD), or medical staff under his/her direct supervision in accordance with the manufacturer’s instruction and the guidance set out within this protocol. Typically, we insert spinal drains in all patients undergoing elective thoracoabdominal aortic surgery. Insertion of a CSFD may be contraindicated in cases of acute trauma, active infection, aortic rupture, prior paraplegia or previous spinal surgery, the consultant anaesthetist fully assesses the patient’s suitability prior to insertion. The insertion of a spinal drain is always carried out under strict and full aseptic conditions. This includes formal ‘scrubbing up’ and the wearing of cap, mask, gown and gloves. Insertion of the CSFD is ideally done after the patient has been anaesthetised and all other arterial and venous lines inserted. Prior to insertion the patient is placed in the right lateral decubitus position with the legs flexed towards the head. The insertion area is draped and sterility ensured. The skin is given a double preparation with alcoholic chlorhexidine and allowed to dry after each coat. Insertion is at a level below the lower end of the spinal cord, preferably L4/5 in order to avoid direct spinal cord injury. The insertion kit is used according to the manufacturer’s instructions. After insertion and ensuring the drain is working, it is carefully secured with sutures that do not occlude it. The dressing should be clear and occlusive and the line should be secured in a way that routes it clear of the likely site of surgical incision.

### 2.3. Lines for monitoring of cerebrospinal fluid pressure and draining fluid

The National Patient Safety Agency (NPSA) was contacted and asked if they recommended that manometer tubing used for spinal drains should be colour coded. They stated that at present there are no recommendations. It was therefore decided by the hospital it would use an individual white manometer tube that is separate from all other manometer lines. Due to inadvertent spinal injections throughout the NHS, manufacturers have been tasked by the NPSA with providing dedicated/unique equipment by 2011. To reduce the risk large red labels are attached next to all

![Fig. 1. Arrangement and designation of cerebrospinal fluid drain.](image1)

![Fig. 2. Arrangement of pressure transducer lines for cerebrospinal fluid drain.](image2)
CSF may cause a precipitate fall in intracranial pressure and lead to tearing of subdural vessels within the patient's skull, leading to cerebral damage from subdural haematoma. If the pressure exceeds a certain level then a three-way tap is turned on the drainage line to allow a controlled release of CSF into the drainage reservoir before turning the tap back again so that the spinal drain is again open only to the transducer. The roller clamp on the line that delivers flush to the transducer is closed and tape wrapped around this clamp to prevent it being rolled open. In addition, a second clamp is applied to the flush line and a label is applied to that which specifically says ‘Do Not Flush’.

2.4. Intraoperative management

After insertion of drain and of establishment of monitoring of pressure, the transducer plate is placed at the mid atrial level. CSF is drained manually by gravity to maintain a CSF pressure of <15 mmHg. CSF is drained in 10 ml aliquots. The hourly turnover of CSF is naturally about 10–20 ml, and normally would expect to have to drain CSF at a rate of about 10 ml/h though the required rate will vary above or below this from patient to patient. In addition, volume removed is recorded.

2.5. Postoperative instructions

Handover of the patient from theatre staff to intensive care unit (ICU) staff is key. There is a high turnover of nurses and junior doctors in any given 24 hours so operative details and postoperative instructions need to be clearly communicated and documented. Ideally, we maintain mean arterial pressure (MAP) >90 mmHg, ICP <15 mmHg and haemoglobin around 10 g/dl. Vasopressors should be used liberally to maintain blood pressure (BP). In some patients keeping ICP <15 mmHg can prove difficult in which case we elevate MAP to maintain SCPP >70 mmHg (SCPP=MAP-ICP). Patients are woken within four hours of their operation for an assessment of their peripheral neurology. Junior staff should feel free to contact senior medical staff if patient parameters deviate from expected. Protocols provide systems which highlight and ensure compliance with expectations. Indeed, our protocols were developed out of necessity as early on in our experience we noted that neurological issues were related to delayed paraplegia and these in turn were related to periods when there were unrecognised signs of cord compromise which were ignored mostly due to lack of education of junior staff.

2.6. Postoperative protocol (5 documents)

The protocol or ‘care bundle’ for reducing the risk of paraplegia is ‘delivered’ through five documents: Documents 1 (Fig. 3), a checklist and handover document for the patient arriving on ICU post surgery; Document 2 (Fig. 4), a bespoke ‘neuro-obs’ chart for recording neurological status following surgery; Document 3 (Fig. 5), a modified version of the COPS protocol [1] for guiding response to neurological impairment and Document 4 (Fig. 6), an aide-memoire for scoring neurological function. Document 5 (Fig. 7) is a bespoke observation chart. Together with the written ‘protocol’ these documents constitute a safe and efficient way of reducing the risk of paraplegia and managing the CSFD.

These documents were developed by surgeons, anaesthetists and nurses involved in the care of these patients. Once formulated the protocol went through a rigorous process of appraisal by existing hospital committees responsible for safety in ICU. All staff caring for patients with a CSFD are expected to adhere closely to the protocols. In cases where delayed neurological deficit (DND) is suspected, the consultant anaesthetist is contacted immediately for advice. If brain is intact and patent then CSF is drained to maintain a pressure of <10 mmHg without limit under the CSF drain status/oxygen delivery/patient status (COPS) approach [2], (Document 3).

2.6.1. Document 1

Document 1 is a checklist, communication tool and aide-memoire to ensure effective management, when the patient arrives in ICU from theatre. It ensures staff had considered the following:

1. The patient’s upper torso is at 30° angle;
2. The transducer height is positioned at the level of the heart;
3. The three-way tap is addressed with the drain bag turned off to the patient and line continuously monitored for ICP pressure. The line is marked as ‘spinal drain’ and ‘not for flushing’;
4. Subcutaneous heparin (5000 U tds) is prescribed;
5. Staff understand that following extubation, CPAP hood or mask should be discussed with responsible consultant. This may be associated with paraplegia [8].

In addition, this document highlights the instructions for a typical patient maintaining MAP >90 mmHg and ICP <15 mmHg. ICP should be drained to 20 ml/h in 5–10 ml aliquots to achieve <15 mmHg. Should this prove difficult within the acquired parameters then MAP should be increased with vasopressors until SCPP >70 mmHg (SCPP=MAP-ICP). Haemoglobin is maintained >10 g/dl. Sedation is ceased after a defined period to assess neurology. If satisfactory sedation is restarted until what time the patient’s respiratory function allows extubation. If neurology is compromised this represents a medical emergency and consultants responsible for the patient should be involved. The neurology should be documented on the chart which described as Document 2.

2.6.2. Documents 2 and 4

Document 2 ensures that early detection of a neurological deficit is noted and with Document 3 is acted upon immediately. The chart emphasises the importance of hourly assessment of GCS, pupil reactivity and power and sensations assessments of the lower limbs. The chart also ensures the staff record ICP, MAP and CSF drained hourly thus further prompting vigilance of these variables. Because most of our nursing staff work in a specialised cardiothoracic ICU, measuring and recording variables, such as GCS, and limb neurology, are not common place. Document 4 provides an immediate reference document to assist nurses in these assessments. In addition, Document 3 also provides the information to doctors on administration of analgesics into the spinal drain. Regulation of this process must be meticulous and error free.
2.6.3. Document 3

Document 3 is pivotal in guiding medical response to any perceived neurological impairment. We have based it on the seminal paper by Estrera et al., from Houston Texas. The so-called ‘COPS’ [1] protocol is initiated to reverse any neurological compromise. Detection of neurological compromise is a medical emergency and its presence must be immediately ‘passed up the line’ to consultant surgeon and anaesthetist. Nursing staff must be educated that paraplegia is not analogous to stroke following cardiac surgery – in which its presence is noted and little can be done. Impaired lower limb neurology must mandate a rapid response. In Professor Estrera’s COPS protocol the following is described, with some modifications:

1. C (Cerebrospinal fluid drainage). Check the drain is functioning properly and is not blocked or kinked or cut. Drain CSF aggressively (slow 10 ml increments as required) and maintain ICP below 10 mmHg. Lying the patient flat may help. The drain should be left in place for seven days rather than the routine three days. If delayed paraplegia occurs after the drain has been removed it should immediately be replaced and the COPS protocol followed.

2. O (Oxygen delivery). An attempt is made to optimise any deficiencies in oxygen delivery. Oxygen saturation should be maintained >95% with supplemental oxygen, either through face mask or endotracheal tube and ventilation. Haemoglobin is supplemented with blood transfusions to maintain it >10 g/dl. In addition, any suspicion of low cardiac output should elicit invasive or non-invasive cardiac output monitoring and inotropes as required.

3. P (Pressure management). Key and central to the response to neurological compromise is manipulation of spinal cord perfusion pressure (SCPP=MAP-ICP). We use vasopressors liberally including noradrenaline and on occasion vasopressin to achieve our target MAP. On occasions when it seems impossible to lower ICP below...
10 mmHg we maintain SCPP by increasing MAP over our target. It goes without saying that the patient should be adequately filled guided by either CVP or PCWP.

4. S (Status of patient). More frequent and accurate neuro observations will be required in this scenario. Discussion occurs between senior doctors regarding the necessity for CT-imaging of the brain and spinal cord.

2.6.4. Document 5

Document 5 was created to ensure staff specifically note and record appropriate observations separate from the usual postoperative cardiac surgery ICU charts. This emphasises the different management of these patients. The document also requires a number of checks are made by nursing staff on each shift relating to the safety of the CSFD. In addition, it also ensures an audit trail is completed.

2.7. Spinal drain and administration of analgesia

In the early stages following thoraco-abdominal aneurysm surgery the patient will have pain from an extensive surgical incision, and will require very good pain relief to enable smooth and early weaning from intermittent positive pressure ventilation (IPPV). While the spinal drain remains in situ, excellent pain relief can be obtained by the administration of intrathecal diamorphine via the spinal drain. This should be at the instigation and under the direction of the consultant anaesthetist. The dose of diamorphine is 0.5–1 mg administered slowly (over three to four minutes) in 5 ml of normal saline. The preparation of intrathecal diamorphine should ideally be done in pharmacy (within the Aseptic Suite) and should therefore be ordered prior to surgery. The administration of the intrathecal injections must involve strict aseptic technique. The duration of action of each injection is about four to six hours, and the injections can safely be repeated. In between each of these injections the injection port/three-way tap on the spinal drain system should remain covered by a gauze swab in order to render any other injection impossible to give inadvertently via this route. Prior to removal of the spinal drain, the patient should be established on Patient Controlled Analgesia (PCA). Document 4 provides information on the safe administration of analgesia via the spinal drain and has reference to the Glasgow Coma Scale.
Neurological deficit

Medical Emergency

Contact on call anaesthetist and/or consultant anaesthetist

[Modified ‘COPS’ protocol (Estrera et al., 2009)]

<table>
<thead>
<tr>
<th>Individual elements</th>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebrospinal fluid drainage</td>
<td>• Check drain function (if not working replace)</td>
</tr>
<tr>
<td></td>
<td>• Lie completely flat</td>
</tr>
<tr>
<td></td>
<td>• ICP &lt;10 mmHg</td>
</tr>
<tr>
<td></td>
<td>• Drainage in 10 ml increments (no more than 20 ml. Will need immediate review by consultant anaesthetist)</td>
</tr>
<tr>
<td></td>
<td>• Keep in for 7 days</td>
</tr>
<tr>
<td></td>
<td>• 5000 U sc heparin tds</td>
</tr>
<tr>
<td>Oxygen delivery</td>
<td>• $O_2$ Saturations &gt;95%</td>
</tr>
<tr>
<td></td>
<td>• Haemoglobin &gt;10 g/dl</td>
</tr>
<tr>
<td></td>
<td>• Cardiac index &gt;205 l/min/BSA</td>
</tr>
<tr>
<td>Pressure management</td>
<td>• MAP &gt;90 mmHg</td>
</tr>
<tr>
<td></td>
<td>• SCPP &gt;80 mmHg (MAP-ICP)</td>
</tr>
<tr>
<td></td>
<td>• Adequate right sided filling pressures</td>
</tr>
<tr>
<td>Status of patient</td>
<td>• Regular neurological observations</td>
</tr>
<tr>
<td></td>
<td>• CT-scan head and spine if paraplegia</td>
</tr>
</tbody>
</table>

Bloodstained CSF

Medical Emergency

Contact on call Anaesthetic and/or Anaesthetic Consultant

Stop draining
Correct coagulopathy
Consider Imaging
Altered mental status or focal deficit - immediate CT

Fig. 5. Document 3 of protocol.

2.8. Trouble shooting spinal drains

Trouble shooting spinal drains is addressed by Estrera et al. [1] and again briefly below.

2.8.1. Displacement of drain dressing

Should a dressing become unstuck, the exposed area is cleaned with aqueous chlorhexidine and allowed to dry before the application of a fresh dressing. This is done as a matter of urgency.

2.8.2. Unable to drain CSF

In cases where drainage is an issue immediately postinsertion, this is usually related to a kinked or blocked catheter. This may be rectified by redressing the catheter making certain to avoid skin folds, while a blocked catheter will need to be replaced. This may be related to extension of the vertebral column post insertion.

2.8.3. Blood stained CSF upon insertion of line

In cases of a ‘bloody tap’, reintroduction of the touhy needle into another intervertebral space needs to be performed. If upon reinsertion of the drain there is still blood in the cerebrospinal fluid that does not clear after 2 ml of fluid, cancellation of the case is considered.

2.8.4. Blood stained CSF postoperatively

Drainage should stop when there is evidence ‘bloody’ or ‘blood-tinged’ CSF and coagulopathy should be corrected. Radiographic CT-testing should be done to exclude intracranial bleeding or a spinal haematoma (Document 3).

Further dangers that are present whenever a spinal drain is in place are: (1) the introduction of infection into the subarachnoid or epidural space; (2) the development of spinal haematoma from the combination of an indwelling line in a potentially coagulopathic patient; (3) the risk of inadvertent injection of drugs down the line if it is mistaken for an intravenous line.

2.9. Avoiding inadvertent IV injections

Once connected to the sterile drainage system, the three-way tap and injection port on this system should have a piece of clean gauze taped around them to distinguish
them from the patient's intravenous (IV) ports and render them difficult to use. This gauze may need to be replaced subsequently and both medical and nursing staff must ensure that inadvertent spinal injections cannot be given.

2.10. Removing the spinal drain

Normally the drain will be in place for 72 hours as this allows a fibrotic response to develop around the catheter, aiding sealing when the catheter is removed. After this time it should be removed. The patient’s blood clotting should be checked and corrected if appropriate. If the patient is on subcutaneous heparin, removal should occur at a time when it is at the lowest point of its action, as for removal of epidural catheters. Low molecular weight heparins are inappropriate while a spinal drain is in place, as is warfarin. Subcutaneous ‘mini hep’ is given usually three times per day (TDS). A dose should be omitted and the drain should be removed eight hours after the previous mini hep dose and eight hours before the next dose. A transparent occlusive dressing should be applied once catheter removed. There may be leakage of fluid from the catheter insertion site, to differentiate whether it is oedema or CSF leakage a sample should be analysed for glucose, cell count, pH, and electrolytes. The anaesthetist must be informed of any suspected CSF leakage postremoval. Treatment involves conservative measures which include bed rest, limiting the patient’s head <30°, and hydration. If this does not resolve after 24 hours then further intervention may be required which will be initiated by the consultant anaesthetist. Unlike epidurals, spinal drains should only ever be nursed in the ICU, not on the wards. As described in Document 3, the presence of neurological impairment should result in the drain being left in situ for seven days.

3. Policy implementation plan

The Lead Consultant Anaesthetist for Risk is responsible for the implementation of this policy and keeping the
detailed implementation plan. The Anaesthetic Division is responsible for monitoring and audit of clinical practice to ensure that it is performed in a safe and appropriate manner and for reviewing the progress in the implementation of this plan. The Clinical leads and Unit Managers for the Surgical Intensive Care Unit (SICU) and Theatres are responsible for ensuring staff are aware and apply this policy, and the appropriate training given. This policy is placed on the Trust’s intranet and hard copies placed on the Surgical Intensive Care Unit and Theatre.

4. Monitoring of compliance

The Surgical, Anaesthetic and Critical Care Risk Committee will be responsible reviewing this policy and the frequency it is review including staff compliance and outcomes.

5. The future

It goes without saying that any institution introducing a protocol should submit the process to a regular and robust audit cycle of effectiveness and compliance. In addition, the protocol should be flexible enough to allow development. Other measures on the horizon may be included within the COPS protocol are interventions, such as post-operative spinal cord cooling [9] and endovascular core cooling [10].

6. Conclusion

There is general agreement, although no randomised controlled trial (RCT) evidence, that spinal drainage as part of a package of interventions contributes to a reduction in the incidence of paraplegia following thoracic aortic surgery. Catheterisation of the subarachnoid space is
potentially dangerous itself and any institution employing this method should have strict protocols in place for its safe and effective use. This manuscript describes a ‘care bundle’ for achieving this aim based on our institutional experience. Further generic information on lumbar spinal drains may be obtained from the following websites: http://www.aann.org/pdf/cpg/aannlumbardrain.pdf and http://www.utoledo.edu/policies/utmc/nursing/standards/E/pdfs/E07b.pdf.

References


