A nursing approach to caring for a baby and their family undergoing ventricular lavage for post haemorrhagic ventricular dilatation

Ventricular lavage is a treatment that aims to reduce pressure and oedema in the brain, by washing as much blood and harmful substances caused by post haemorrhagic ventricular dilatation (PHVD) as possible out of the brain. The authors discuss the history of the DRIFT trial, which led to ventricular lavage, along with information on the nursing roles and responsibilities of caring for an infant undergoing treatment.

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Key points

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1. The DRIFT trial showed that washing blood and harmful substances caused by PHVD out of the brain can significantly reduce cognitive disability in infants at two years of age.
2. DRIFT also known as ventricular lavage is a highly complex procedure that requires training and nursing care on a 1:1 basis throughout treatment.
3. More research is required for NICE to consider ventricular lavage as a treatment recommendation for the NHS.

Intraventricular haemorrhage (IVH) is one of the most dangerous complications of preterm birth, affecting 21% of infants weighing less than 1000 grams, and 12% of those weighing 1001-1500 grams[1,2]. A large IVH classified as Grade III or IV by Davies et al[3], often leads to post-haemorrhagic ventricular dilatation (PHVD)[2,4,5]. The incidence of a Grade III IVH is 5.9% in infants weighing ≤1000 grams and 3.7% in infants weighing ≤1500 grams, whereas a Grade V IVH occurs in 9.4% of infants weighing ≤1000 grams and 4.9% of infants weighing ≤1500 grams[6]. PHVD is caused by multiple blood clots blocking the re-absorption of cerebrospinal fluid (CSF). If PHVD is progressive and persistent with excessive head enlargement, the infant becomes dependent on a ventriculo-peritoneal (VP) shunt for the remainder of his or her life[2,4,5]. In addition to the hazards of a VP shunt, children with PHVD have a high risk of cerebral palsy, learning disability and significant risk of epilepsy, visual and hearing loss[7,8]. Although some of the disability is due to early haemorrhagic infarction, there is evidence of progressive global injury occurring to the brain over many weeks due to pressure, distortion and toxic substances released from the old blood in the CSF. These toxic substances include free iron, pro-inflammatory cytokines, hypoxanthine and bilirubin[9,10].

Many different treatments have been used for PHVD. Repeated lumbar punctures, drugs to reduce CSF production and intraventricular streptokinase have all been tested in randomised trials without any evidence of efficacy[11]. Tapping a ventricular reservoir and external ventricular drainage have been tried but not tested in randomised trials. Insertion of an early VP shunt is not technically possible in a tiny infant with ventricles full of blood[2,4,5].

Since no therapy had been proven to be successful, in 1998, Whitelaw and Pople[2] piloted Drainage, Irrigation and Fibrinolytic Therapy (DRIFT). DRIFT aimed to reduce pressure and oedema in the brain, by washing as much blood and harmful substances caused by PHVD as possible out of the brain in order to improve the outcome for these brain-injured infants[2]. After a feasibility study, a randomised trial was mounted. The DRIFT trial recruited infants with PHVD during 2003-6. As the trial showed a very significant reduction in severe cognitive disability at two years[5], there is now considerable interest in DRIFT (also known as ventricular lavage), which is currently the only intervention which has shown any benefit to infants with PHVD. A larger multicentre DRIFT 2 trial is currently being planned. The purpose of this article is to describe how infants are nursed during ventricular lavage.

Ventricular lavage as a treatment

Southmead Hospital was given permission to offer DRIFT as a treatment in 2010. This came after it was assessed for clinical effectiveness, had a risk assessment and was given legal clearance. A tariff for the treatment was also configured to ensure

centres would know how much the treatment would cost them. Ventricular lavage replaced the name DRIFT because human recombinant tissue plasmingen activator (rTPA) (Actilyse, Boehringer Ingelheim International GmbH, Ingelheim, Germany) was not used in the standard ventricular lavage treatment initially, as had been the case in the DRIFT trial, due to its possible association with secondary bleeding. rTPA is a thrombolytic agent which degrades fibrin, and so breaks up thrombi (blood clots)[12]. However, as more babies have been treated, rTPA was found to be essential to enable thrombolytic break down, ensuring greater clearance by ventricular lavage of any thrombi, thus enabling maximum efficiency of treatment. Due to this finding the use of rTPA has become standard practice in ventricular lavage over recent months. To December 2011 Southmead hospital has carried out ventricular lavage on 16 infants.

Preparation for treatment

Once the infant has been found to be eligible for treatment (see **FIGURE 1**) and prior to treatment commencing, it is the nurse's responsibility to ensure that the parents have the opportunity to discuss this treatment with medical staff, and that they have been provided with an information leaflet[14]. It is essential that parents are able to make an informed decision and be involved in all aspects of the care of their baby[15]. Once the parents have decided to go ahead with treatment it is a legal requirement that they sign a consent form in the presence of the neurosurgeon who will be carrying out the surgery to insert the catheters[16]. Consent is only valid when the information provided has been understood by the parents, and the reason for intervention is explained, along with the possible risks/side effects, and an explanation of the implication of refusing consent is given[16].

On the day of the insertion of the catheters, and for the remainder of treatment, nursing care of the baby undergoing ventricular lavage must always be done on a 1:1 basis. It is the responsibility of the nurse to ensure that all the equipment required to perform ventricular lavage is available. A nursing checklist has been devised to ensure that nursing staff are aware of exactly what is necessary for the treatment to go ahead. Prior to treatment the nursing and medical team must ensure that the infant's platelets and clotting factors are within acceptable limits, and a dose of vitamin K must be given if the infant has not had a dose within the last week.

Ventricular lavage inclusion criteria

- Intraventricular haemorrhage documented on ultrasound.

PLUS

- Age less than 28 days

PLUS

- Progressive dilatation of the each lateral ventricle defined as:
  a) Ventricular width 4mm over the 97th centile of Levene[12]

OR ALL THREE OF THE FOLLOWING:

a) Anterior horn diagonal width 4mm (1mm over 97th centile of Davies[3])

b) Thalamo-occipital distance 26mm (1mm over 97th centile of Davies[3])

c) Third ventricle width 3mm (1mm over 97th centile of Davies[3])

OR

- Measurements above one of the above criteria on one side combined with obvious midline shift indicating a pressure effect.

Exclusion criteria

Generalised bleeding tendency:

PT >20 seconds

OR

APTT >50 seconds

OR

Platelets <50x10^9/L

An infant may become eligible if the above abnormalities are corrected.

FIGURE 1 Eligibility for ventricular lavage treatment

Source: Whitelaw A., Evans D., Carter M., et al. Randomized clinical trial of prevention of hydrocephalus after intraventricular hemorrhage in preterm infants: brain-washing versus tapping fluid. *Pediatrics* 2007;119e1071-8.

The infant must then be transfered into an open incubator and intubated (if not already), several hours prior to the insertion of the drains to allow the infant to stabilise. Prior to the surgeon inserting the catheters for treatment the infant must be sedated, paralysed and given pain relief. This is achieved by the administration of morphine (400µg/kg), and pancuronium (100µg/kg), along with an infusion of up to 40µg/kg/hr of morphine, to make sure the infant remains comfortable throughout catheter insertion.

Once the infant is adequately sedated and paralysed it is important that a blood gas is taken within 30 minutes to ensure that the PCO_2 and pH are within the acceptable ranges before the neurosurgeon arrives, to ensure that the optimum ventilation is achieved during paralysis. It is sometimes necessary to give the infant a further 100µg/kg of pancuronium immediately prior to the insertion of the catheters to ensure that the infant remains paralysed, however this is very much on an individual basis. It is therefore essential that there is a doctor available at all times, just before and during the procedure, so that any additional pain relief/sedation can be prescribed and administered.

Once the medical and nursing team is confident that the infant's condition is stable and there is adequate sedation, pain relief and paralysis, all unnecessary people in the intensive care unit are asked to leave, so that the procedure can be carried out as a sterile/aseptic procedure and with minimal disruption. The nurse caring for the infant places screens around the cot space to ensure privacy at all times.

Catheter insertion

The surgeon commences by shaving the infant's hair from the right frontal area to the fontanelle and over the left lambdoid suture. This area is cleaned thoroughly and a local anaesthetic (0.5% or more dilute lignocaine in adrenaline) is injected around the area of drain insertion. The neurosurgeon then makes a very small hole in the skin with a scalpel blade and inserts an arterial dilator to a pre-estimated depth, decided by reviewing the infant's routine cranial ultrasounds performed prior to treatment[2]. A Scott ventricular cannula is inserted into one of the lateral ventricles anterially until CSF comes out, then it is secured with a suture and covered with a clear dressing applied to form a seal. Two three-way taps are attached to the end of the catheter. The procedure is then repeated into the opposite lateral ventricle, but positioned posteriorly so that there is an anterior and a posterior drain (see **FIGURE 2**)[2]. The position of the catheters has been standardised regardless of where the IVH has occurred, or if multiple IVHs are present. Pressure changes within the ventricles during treatment further facilitate movement of CSF across the ventricles, therefore ensuring ventricular lavage is achieved. Throughout the procedure it is essential that the nurse monitors the infant's vital signs, and if the infant shows any signs of being uncomfortable, a further bolus of morphine can be given.

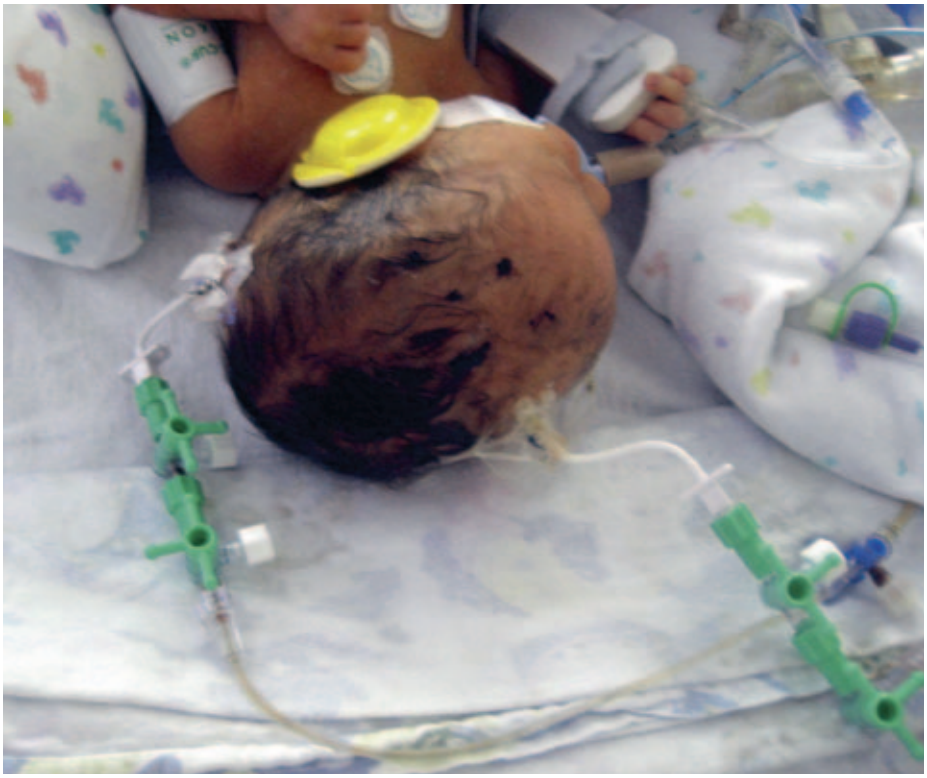

FIGURE 2 Positioning of the cannulae for ventricular lavage.

Post catheter insertion

Once the drains have been inserted and the infant is stable, a sample of CSF is sent for microbiology and protein analysis. After 1-2 hours post surgery, 0.25mg/kg of rTPA is then injected into each catheter via one of the the three-way taps by a doctor and left for eight hours (or overnight), to allow any clots time to breakdown.

The next stage of treatment involves a Codman external ventricular drainage system (Johnson & Johnson, Piscataway, NJ, USA) which is connected to the posterior catheter. This allows sampling and up to 70mL of CSF to be collected in a small reservoir, and is used to establish the initial height of the drain in line with the centre of the infant's head which is then marked as 'zero'. Below this reservoir there is a larger collecting bag with a capacity of 500mL. Once 'zero' has been established, the height of the incubator must not be altered. The nurse must place signs stating this on the pedals of the open incubator as a reminder to all staff.

To the anterior drain artificial CSF is primed through a giving set with a filter, connected via a pump and attached to one of the three-way taps. The artificial CSF is supplied by pharmacy as two parts. Part 1 is in a 500mL glass bottle, which then has part 2 (5mL ampoule) added to it, along with 10mg of vancomycin (the usual intravenous preparation is used as it contains no preservatives). Also added is 5mg of intrathecal gentamicin (this has to be an intrathecal preparation as intravenous gentamicin contains preservatives). All components of the artificial CSF are prescribed on an intrathecal prescription chart and due to the stability of the preparation it is reformulated and changed by nursing staff every 12 hours. The artificial CSF is prepared using strict aseptic non-touch technique, which is essential to prevent infection as the artificial CSF will be entering the infant's brain.

A pressure transducer primed with normal saline is connected to the anterior catheter via the three-way tap, in order to record the infant's intracranial pressure (ICP) throughout treatment (see **FIGURE 3**). Once this is connected, the pressure transducer needs to be carefully zeroed. This is achieved by opening the transducer to air in line with the centre of the infant's head.

Commencing treatment

The exterior drain from the posterior catheter is usually left to drain for 30 minutes to ensure a negative balance is achieved at the beginning of treatment. After 30 minutes of draining, and once the infant's ICP is within acceptable limits (≤6mmHg), the artificial CSF is set to run at 21mL/hr. At each 30-minute interval, the nurse records how much fluid has drained into the reservoir, documents the colour of the CSF, and empties this into the 500mL collecting bag (see **FIGURE 4**).

The rate of drainage must be carefully observed, especially within the first two hours of treatment. It is essential to maintain a strict fluid balance of the CSF. The aim is to drain 5-10mL/kg of CSF within the first hour. If the infant's ICP is higher than 6mmHg, it may be necessary to drain more CSF to lower the ICP. However, it is essential that the nurse does not allow ≥20mL/kg/hr CSF to drain, as this rapid loss could cause the infant to go into shock, increasing the risk of a secondary bleed. To adjust the rate of drainage, the nurse must raise or lower the reservoir.

Throughout the normal course of ventricular lavage treatment, regardless of the infant's weight, 10mL of artificial CSF is infused every 30 minutes with an anticipated output of 10-12mL drained. This is to ensure a stable ICP of ≤6mmHg is achieved and to prevent any rapid dilatation or collapse of the infant's ventricles.

Regular ultrasound head scans are performed to assess the size of the ventricles, and this enables the nurses to decide how much of a loss to aim for depending on any ventricular dilatation or collapse observed. Every infant's needs are different, however, usually a 1-2mL loss above the 10mL infused in every 30 minute cycle is acceptable due to the infant's own natural production of CSF. The initial CSF draining out is usually cola in colour, and over time this should eventually be the colour of white wine. Treatment lasts for a minimum of 72 hours, but if the CSF remains quite dark and the infant's condition is stable, treatment can go on as long as one week[2].

Recording true ICP

The infant's ICP is continuously monitored during the procedure with an upper alarm limit set to alarm if it exceeds 6mmHg. The pressure of the infusion can increase the ICP measurement by 1-2mmHg, therefore, every 30 minutes the infant's 'true' ICP must be documented. This is done by turning the three-way tap connected between the ICP transducer and the artificial CSF infusion off to the infusion. It is also essential that every time the infant's head position is changed, or an unusual ICP measurement is shown (or at least

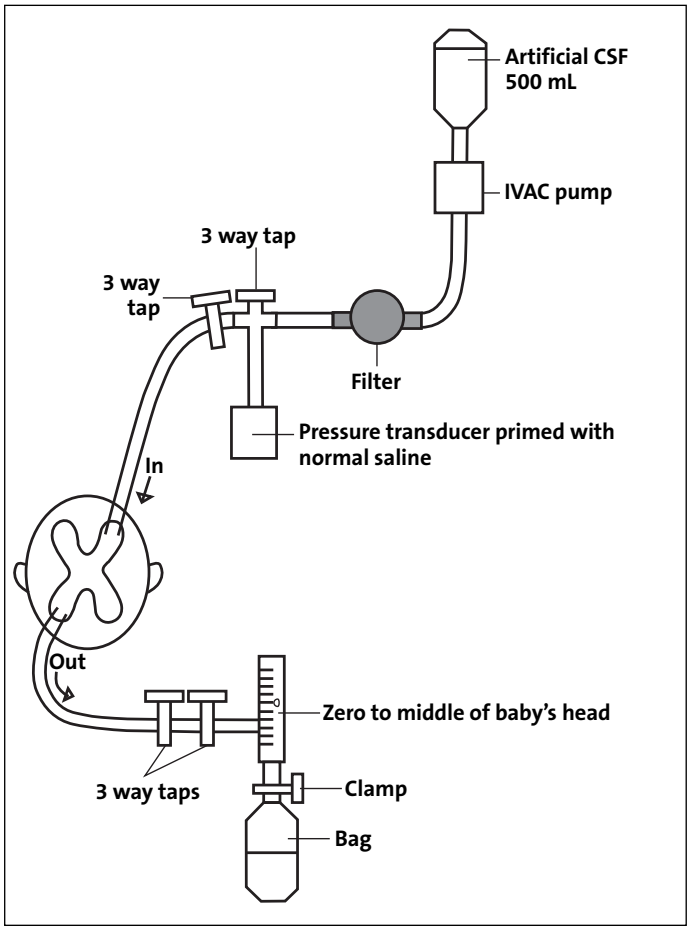

FIGURE 3 Diagram of ventricular lavage set up.
Source: Whitelaw A., Pople I., Cherian S., et al. Phase 1 Trial of prevention of hydrocephalus after intraventricular hemorrhage in newborn infants by Drainage, Irrigation, and Fibrinolytic Therapy. *Pediatrics* 2003;111:759-65.

FIGURE 4 Measuring the volume of fluid drained from the infant.

eight hourly) the ICP transducer is zeroed in line with the centre of the infant's head (as explained above), to ensure its accuracy.

Trouble shooting

If the drained volume is less than 10mL in any 30-minute period but the infant's ICP is less than 6mmHg, the nurse must lower the height of the reservoir by 1cm and continue infusing and draining CSF. However, if the ICP is greater than 6mmHg, the infusion must be stopped and the draining continued, but the reservoir must be lowered by 2cm. When the ICP has fallen below 6mmHg, the infusion can recommence.

If the rate of drainage decreases and the ICP remains over 6mmHg it is essential that the nurse stops the infusion (continuing to drain), and informs the medical team who will need to investigate the cause of this. If the infant's ICP is raised for a prolonged period it can result in damage to the infant's brain. The increased ICP can often be due to a blockage from a clot that the doctors can attempt to flush out. If this is unsuccessful then a second dose of rTPA may be necessary to unblock the catheters. On some occasions it has been necessary to swap the anterior and the posterior catheters to reverse the flow, thus flushing the clot back into the ventricle and enabling the catheters to drain freely. This process often encourages the clot to break down further allowing it to pass through the opposite catheter (the anterior catheter will then be connected to the drainage system, and the posterior catheter will be used to infuse the artificial CSF). A blockage occurring between the right and left ventricles would cause one ventricle to be larger than the other and could be resolved by carrying out the above process, along with positioning the infant's head so that the dilated ventricle is uppermost.

Possible risks/side effects of treatment

Ventricular lavage is a highly technical and invasive procedure that has some risks/side effects that nursing staff need to be able to recognise and manage, in order for treatment to be successful, eg there is a risk of a secondary haemorrhage,which is increased if the infant is particularly active. Nursing staff should ensure that the infant is comfortable throughout, firstly by using non-medical means such as positioning aids, ensuring that noise/light etc are kept to a minimum. If these methods are unsuccessful further pain relief, and often muscle relaxants may be necessary. If despite these efforts the infant shows clinical signs of having a secondary haemorrhage such as, becoming pale, starting to have jittery movements, increase in heart rate and decrease in blood pressure, the medical team must be informed immediately.

In addition to having a secondary haemorrhage, there is a risk of the infant acquiring a CSF infection. Daily sampling of drainage fluid for bacterial and microscopic testing helps to detect any infection. If infection is suspected, this may be treated with intravenous vancomycin and cefotaxime, while ventricular lavage continues.

Very occasionally the catheter sites have been found to leak CSF. The nurse caring

for the infant must observe for signs of this and will need to try to measure any leakage, ensuring that this is added to the total CSF losses. It may be necessary for the neurosurgeon to re-suture/re-dress the catheter site to prevent further leakage.

Nursing competencies

Due to the complexity of caring for an infant and their family while undergoing ventricular lavage, it is essential to have a dedicated team of nursing staff that has a specific interest in ventricular lavage to ensure that high standards of care are met. The team in Southmead Hospital has devised a set of guidelines for medical and nursing staff including a ventricular lavage checklist, care plan and nursing competencies. It is vital that staff undergo training and achieve the competencies required to care for these infants and their families[15].

Family-centered care

Giving birth to a premature infant is an extremely stressful experience for any parent[17]. They are often not prepared for the birth, physically, emotionally or psychologically[18-19]. Having an unwell infant requiring complex treatments such as ventricular lavage can have an impact on all aspects of the parents' lives[20]. During any infant's stay on NICU at Southmead Hospital family-centered care is of paramount importance. Infants often come to Southmead Hospital for ventricular lavage from different areas of the country, so accommodation is always provided for parents so that they can be near their baby during this particularly stressful time. Parents are regularly updated and the doctors take time to show, and explain to parents their baby's daily ultrasound head scans to ensure they have a good understanding of what is happening and the aim of ventricular lavage.

Due to the complexity of the treatment, which can often last for up to one week, parents are unable to hold their baby but staff involve parents as much as they wish to be in the other aspects of their baby's care. Nursing staff can also teach parents how to touch their infant in a way that can minimise any stress the infant may be feeling, which consequently may help to alleviate parental anxiety[21]. Parents are also offered the opportunity to spend time with a clinical psychologist if it is thought they would benefit from some extra support.

The future

Ventricular lavage (or DRIFT which is now the preferred name because rTPA has recently become standard practice again) has been considered by NICE to be offered as a treatment recommendation for the NHS. However they have concluded that the initial trial based on 77 babies provides insufficient evidence to do so[22]. Thus there are plans for a DRIFT 2 trial to take place that will be larger than the initial DRIFT study, requiring at least four centres with a named neonatologist with a specific interest in neurology and a named paediatric neurosurgeon. It is essential that neonatology and neurosurgery are closely linked, which means options are restricted in the UK due to limited centres offering both services.

In preparation for DRIFT 2, the team at Southmead are working to simplify ventricular lavage to make it easier and safer to perform and teach.

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