CASE REPORT

Ventriculoperitoneal shunt disconnection associated with spontaneous knot formation in the peritoneal catheter

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SUMMARY

A 10-year-old girl underwent distal ventriculoperitoneal (VP) shunt revision 3 weeks earlier and developed further shunt malfunction. During the current shunt revision, a disconnection at the straight connector site in the cervical subcutaneous tissue was confirmed and a knot was identified in the peritoneal catheter. Postoperatively, the patient made a rapid neurological recovery and was discharged 48 h later. This is the first case of VP shunt disconnection associated with a spontaneous distal knot formation. The likely mechanism was that the spontaneously formed knot acted as an anchor at the peritoneal wall, preventing free relative movement of the distal catheter. The resultant tension led to failure at the weakest point of the system, resulting in a disconnection at the proximal straight connector site.

BACKGROUND

Cerebrospinal fluid ventriculoperitoneal (VP) shunt malfunction is common, but that owing to spontaneous knot formation is rare. The authors report a case of distal catheter knot formation causing a proximal straight connector disconnection, leading to shunt malfunction. The diagnosis became apparent intraoperatively, and following a shunt revision, the patient made full recovery. Proximal shunt disconnection secondary to a distal knot formation has not been described previously. This case not only adds to the recognised mechanical causes of shunt malfunction, it highlights a general principle that both the mobile and connecting parts of an implant are at risk of mechanical complications. More importantly, if the site and nature of shunt malfunction are identified preoperatively, the length and morbidity of revision surgery can be reduced.

CASE PRESENTATION

A 10-year-old girl with a right ventriculoperitoneal shunt in situ and a background of diplegic cerebral palsy and learning difficulty was found unrousable by her parents in the morning. Prior to this she had a 1-day history of headache, vomiting and non-specific abdominal discomfort. Three weeks earlier, the child had undergone a VP shunt revision, where a new antibiotic-impregnated distal catheter (Codman Hakim Bactiseal, 120 cm) was inserted. It was connected with a straight connector at approximately 1 cm distal to the existing valve.

On examination, the Glasgow Coma Score was 7/15 with the child not opening eyes or making verbal response but localising to pain. The abdomen was soft with a well-healed scar in the right-upper-quadrant.

INVESTIGATIONS

CT scan of the head confirmed hydrocephalus with a satisfactorily positioned right ventricular catheter. There was also a second disconnected catheter which had been tied off and left in situ in one of the earlier revisions. Shunt series showed a disconnection at the cervical region (figure 1A). The recently attached straight connector, which was still tied to the distal catheter, was at the level of T12/L1 (figure 1B). A portion of old shunt tubing was also identified in the cervical region (figure 1A).

TREATMENT

The patient underwent a shunt revision. The abdominal incision was reopened and on retrieving the distal catheter it was found to have a knot at 13 cm from the distal tip (figure 2). The original shunt system consisting of a Medtronic Delta Valve (Neonatal, Performance Level 1.5) was replaced by an entirely new Medtronic Delta Unitised Shunt, consisting of integral barium-impregnated ventricular and peritoneal (90 cm) catheters connected to a regular performance level 1.5 valve. An integral system, which avoided extra connections between the catheters and the valve component, was selected to reduce further risk of disconnection. At the time of revision, an integral system with an antibiotic-impregnated peritoneal catheter was not available.

OUTCOME AND FOLLOW-UP

The patient made an immediate uncomplicated recovery and was discharged 48 h later. CT scan of the head 8 days following surgery confirmed that the ventricular catheter was positioned satisfactorily and the hydrocephalus had resolved. In retrospect, the abdominal radiograph performed as part of the shunt series prior to the revision did suggest the presence of a knot (figure 1C).

DISCUSSION

We describe a case of proximal shunt disconnection associated with a knot formation in the peritoneal catheter. Normally, a distal catheter is able to slide in and out of the peritoneum with body movement

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Figure 1 (A) Lateral skull plain radiograph showing disconnection of shunt 1 cm distal to the valve (black arrowhead). Shunt tubing including a straight connector in the neck is not the distal part of the current disconnection (white arrowhead). It is a piece of retained tubing from revision surgery 3 weeks ago. (B) Chest and (C) abdominal radiographs showing disconnected distal catheter (black arrowhead). Retrospectively, a knot is seen in the right lower quadrant (white arrowhead).

and respiration. In this case, the knot acted as an anchor at the peritoneal wall, preventing free relative movement of the distal catheter. The resultant tension, exacerbated by neck rotation and trunk extension, led to failure at the weakest point of the system, resulting in a disconnection at the straight connector site. It is likely that the knot was formed during shunt revision 3 weeks before the current admission. The patient had multiple shunt revisions in the past and therefore her peritoneal space was reduced owing to intra-abdominal adhesions. This increased

the chance of knot formation when the distal shunt tube was inserted.

Spontaneous knot formation is a rare cause of shunt malfunction.¹⁻⁴ The exact mechanism for spontaneous knot formation is unknown. Bowel peristalsis has been suggested as a factor inducing knot formation.²⁻³ Eftekhari *et al*³ suggested that the underlying mechanism of knot formation might be a combination of (1) catheter related factors (such as dimensions and physical properties and insertion technique) and (2) patient related factors (including volume and configuration of abdomen and kinetics of catheter movement). Whatever the mechanism of knot formation, in all of the reported cases so far shunt malfunction has been a blockage secondary to narrowing of the lumen at the site of the knot.¹⁻⁴ In the present case, shunt malfunction possibly occurred secondary to disconnection of the proximal catheter at the connector site. Including the present case, three out of five of the known shunt malfunctions secondary to knot formation occurred within 2 months following the last shunt insertion or revision. Therefore, contrary to Eftekhari *et al*, insertion technique could be a major contributing factor. Although this is a rare complication, we make two recommendations to reduce the risk of shunt peritoneal catheter knot formation

1. During insertion of the peritoneal catheter, the surgeons should avoid inadvertently forming a knot, especially in patients with limited peritoneal space, owing to either small abdominal size, or intra-abdominal adhesions.

To ensure there is sufficient peritoneal space, the surgeon can tent the peritoneal wall up by lifting the Halstead mosquito artery forceps that are holding the edges of the peritoneal opening. The potential space can then be directly visualised. In addition, a blunt instrument, for example, Watson Cheyne dissector, can be used to confirm if there is a potential space.

To reduce the risk of knot formation, the surgeon should pass the peritoneal catheter with non-toothed/rubber-shod forceps as deeply as possible and towards the right pericolic gutter. This is to prevent convolution of shunt tubing near the site of insertion.

2. If a shunt fracture is in close proximity of a valve, consider replacing the catheter and avoid using a straight connector.

Owing to the very different features of the current case and previous reports, no single risk factor for spontaneous knot formation can be identified.

Figure 2 (A) The entire distal catheter contained a knot 13 cm from the distal tip and associated loop measuring 20 cm (black arrowhead). The straight connector can be seen still tied to the proximal end of the catheter (white arrowhead). (B) A close-up view of the knot.

Learning points

- ▶ The freely mobile part (distal peritoneal end) and the weak part (straight connector site) of a shunt are at risk of mechanical malfunction, namely knot formation and disconnection.
- ▶ On reviewing a shunt series in patients with shunt malfunction, one should exclude knot formation as well as discontinuity and dislocation of the shunt tube.
- ▶ During insertion of the peritoneal catheter, the surgeons should avoid inadvertently forming a knot, especially in patients with limited peritoneal space, owing to either small abdominal size, or abdominal adhesions.

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