**Does appendicitis in a child with a ventriculoperitoneal shunt necessitate shunt revision?**

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**Conflict of Interest**

PJ, JJ, DFK and SBD have no conflicts of interest.

**Question**

In children with a ventriculoperitoneal (VP) shunt *in situ*, is shunt externalisation of the abdominal portion mandatory in acute appendicitis?

**Case vignette**

An 8 year-old boy with a long-term ventriculoperitoneal (VP) shunt presented to the emergency department with right iliac fossa pain, nausea and vomiting. Abdominal

ultrasound showed likely appendicitis. We wondered whether in a child with a VP shunt *in situ* with appendicitis, should the shunt always be removed and what antibiotic regimen should be used?

**Search**

Pubmed: “ventriculoperitoneal” AND “shunt” AND “appendicitis” OR “peritonitis”

Returned 89 results – of these 6 were relevant to our questions. The other 83 articles were excluded as they focussed on bowel pathologies other than appendicitis, only included patients with primary VP shunt problems or were evaluating different surgical techniques.

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| Citation | Study group | Study Outcomes | Key results | Comments |
| Ein et al, J Pediatr Surg., 20061 | Case study of 8 children (age 8-17y) with VP shunts undergoing emergency appendicectomy.-3 perforated appendicitis-5 acute, non-perforated appendicitis(4) | Retrospective analysis of records for:-Peritoneal cultures -Antibiotic regimen-Postoperative complications | -Shunt pre-emptively externalised in 3 children with a perforated appendix and left in situ in 5 children with non-perforated appendices.-No ascending shunt infections.-2 peritoneal cultures grew *E. coli*-Four children required shunt revisions 3 months to 4 years post-op due to infection.  | -Follow up ranged from 1-30 years. -Unclear if those requiring shunt revision had complications related to appendicitis or unrelated issue. |
| Pumberger et al, Pedatr Neurosurg 19982 | Case study of 6 children (age 2.5-9y) with VP shunts undergoing emergency appendicectomy.-3 perforated appendicitis -3 acute, non-perforated, appendicitis(4) | Retrospective analysis of records for:-Postoperative complications-Cultures of cerebrospinal fluid (CSF) / peritoneal fluid  | -All children had shunts left in place.-1 patient developed a CSF pseudocyst, necessitating conversion to a ventriculoatrial (VA) shunt.-1 patient was converted to a VA shunt as the VP shunt had disconnected (pre-operatively)-No ascending shunt infection occurred -Peritoneal cultures were negative or grew typical gastrointestinal organisms. All CSF cultures were negative. | -Cases occurred over 8-year period. -Follow-up ranged from 10 months to 9 years. |
| Barina et al, J Surg Res., 20073 | Case study of 5 **adults** with VP shunts who underwent appendicectomy -4 perforated appendicitis -1 gangrenous appendicitis(4) | Retrospective analysis of:-Presentation-Clinical course-Post-operative complications | -1 patient with perforated appendix pre-emptively converted to ventriculoatrial shunt. -1 patient with perforated appendix had shunt ‘discontinued’ when culture of intra-operative peritoneal fluid grew Gram-positive cocci. -No ascending shunt infections | -Cases occurred over 10-year period. -Very little microbiological information included. -Unclear if ‘discontinued’ shunt converted to VA or other solution found.  |
| Hadani et al, Surg. Neurology, 19824 | Case reports of 2 patients Patient 1: 14yr old with phlegmonous appendixPatient 2: 7yr old male with perforated appendix (4) | Case reports including initial presentation, investigations and operative course | -Both shunts externalised prior to appendicectomy.-Patient 1 recovered quickly. Cultures all negative. VP shunt permanently removed as unnecessary.-Patient 2 became septic. Grew *E. coli* in peritoneal and blood cultures. Treated with gentamicin and clindamycin. CSF cultures initially negative then grew *E. coli* after 1 week. Child later died from probable ventriculitis. |  -Patient 2 initially admitted to local hospital for 3 days before transfer to tertiary unit. Neither gentamicin or clindamycin have good CSF penetration. |
| Haussler B et al, Eur J Pediatr Surg. 20015 | Case study of children with appendicitis over 30-year period-7 acute, non-perforated appendicitis-4 perforated appendicitis(4) | Retrospective analysis of clinical course for: -Post-operative complication rate-Culture results | -All shunts initially left in situ-4 perforated appendicitis: 2 developed pseudocysts, 3 required external drainage.-7 acute appendicitis: 1 developed recurrent pseudocyst and converted to VA shunt. 1 developed CSF infection – shunt then externalised.-Organisms grown inc. *Staphlyococcus albus* and *E. coli* | -No follow up included.-Little detail on individual cases.-Unclear source of organisms grown. |
| Dalfino et al, J. Neurosurg. Pediatrics, 20126 | Case study of 7 patients with VP shunts treated for acute peritonitis due a range of causes.2 children (aged 4y and 6y) with ruptured appendixOther cases excluded from analysis here. (4) | Retrospective analysis of clinical course including:-Operation performed, antibiotic regimen used, results of CSF samples -Post-operative and long-term complications | -All shunts left in place-Antibiotic regimen was selected based on sensitivities of organisms grown from peritoneal samples.-No post-op complications occurred.-Followed up for 21 and 18 months respectively, no complications. | -CSF cultures not performed.-Antibiotic regimen provided:Patient 1 - piperacillin-tazobactam (NB: this has poor CSF penetration) for 5 days, then meropenem for 9 days.Patient 2 - ampicillin/sulbactam, metronidazole and meropenem for 14 days. |

**Commentary**

This systematic review demonstrates there are only a limited number of cases reported in the literature of children and adults with VP shunts being managed for appendicitis (Box 1). The details of each report are very heterogenous making it difficult to draw clear conclusions. Each of the studies has limitations. The rarity of these cases results in reports spanning decades during which time many clinical factors are almost certain to have substantially differed. Barina et al3 only included adult cases with no paediatric data. Haussler et al5 include the largest number of cases but give few details on the exact nature of each case or the complications which occurred. A number of the studies did not provide any long-term follow up. In addition, there is little or no discussion of microbiology results and the consequent antibiotic choices.

Box 1: The cumulative figures for acute post-operative complications for the above studies.

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| **Shunt left *in situ**** 12 patients with perforated appendicitis
	+ 3 requiring externalisation
	+ 2 requiring conversion to VA shunt.
	+ 1 had shunt ‘discontinued’
* 16 patients with non-perforated appendicitis:
	+ 1 requiring externalisation
	+ 1 requiring conversion to VA shunt
	+ 1 collection in pouch of Douglas, treated successfully with antibiotics and shunt left in situ
 |
| **Shunt pre-emptively removed** * 5 patients with perforated appendicitis
	+ 1 patient pre-emptively switched to VA shunt
	+ 1 patient died from *E. coli* septicaemia and probable ventriculitis
* 1 patient with non-perforated appendicitis – no complications
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These data suggest the risk of ascending shunt infection is low in non-perforated appendicitis. In cases of perforated appendicitis, the picture is more complicated. Here the risk of shunt infection and other complications appears higher, although this is predominantly based on the findings of the study by Haussler et al5. In addition, trying to draw conclusions about the exact cause of complications such as CSF pseudocysts with so many variables not accounted for is exceedingly difficult. In these cases of perforated appendicitis, the risk of developing a shunt infection secondary to peritonitis must also be balanced against the risk of revising the shunt. One meta-analysis by Ramanan and colleagues7 demonstrated an incidence rate of CSF infections for externalised ventricular devices of 11.4 per 1000-catheter days.

The limited data in these studies suggest shunt removal should not be mandatory in patients with appendicitis, particularly if the appendix is not perforated, but needs careful consideration based on the clinical and microbiological findings. There is insufficient data to suggest an empiric antibiotic regimen and thus this should be made on a case by case basis in accordance with local protocols and in conjunction with a microbiology or infectious diseases expert.

**Clinical bottom line**

1. If the appendix is not perforated the risk of shunt infection is low, therefore, consideration should be given to leaving the original shunt *in situ*. (Grade C)
2. Whilst a perforated appendix is not an absolute indication for externalisation of the shunt, clinicians should have a low threshold for externalisation based on the clinical status of the child and the intra-operative findings. (Grade C)
3. Choice of antibiotics will depend on the results of blood, peritoneal and CSF cultures and should include those with adequate CSF penetration. (Grade D)

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