Blunt pancreatic injury in children

REVIEW ARTICLE

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BACKGROUND

Pancreatic injuries in children are rare and most often caused by mechanisms of blunt injury. Injury to the pancreas in children may be difficult to diagnose and treat.

MATERIAL AND METHOD

The article is based on literature searches in PubMed from the last 10 years (performed on 20 October 2015 and terminating on 20 October 2016) and on the authors' own clinical experience and knowledge of the literature.

RESULTS

The search yielded a total of 20 articles, of which 6 concerned diagnostics and 14 dealt with treatment. Pancreatic injuries are rare and constitute around 0.3 % of all injuries in children, and 0.6 % of all abdominal traumas. Pancreatic injury is the fourth most frequent abdominal organ injury in children, and most occur in the age group 5 – 18 years. A little less than one fifth are isolated injuries. Computed tomography is the first choice in diagnostics, supported by magnetic resonance cholangiopancreatography to achieve optimum sensitivity. Where findings are unclear or pancreatic duct injury is suspected, early endoscopic resonance cholangiopancreatography and stent treatment are relevant to determine pancreatic duct injury. Less severe (grade I–II) injuries are treated conservatively. The choice of surgery or conservative treatment of severe injuries (grade III–V) where the pancreatic duct is involved must be considered for each individual patient. Mortality is generally associated with other severe traumas such as head injuries and multiple organ injuries.

INTERPRETATION

Pancreatic injuries resulting from blunt trauma are rare in children and in most cases can be managed by observation. The evidence base is scant, particularly for severe injuries.

Injury to internal organs is a leading cause of death and disability in children and adolescents (1). Among older children and teenagers, almost half of all fatalities are caused by external events; the most common mechanisms are traffic accidents, violence and falls. Of all injuries, those occurring most frequently in children are head trauma and extremity injury, and abdominal injuries comprise only about 10 % of the total share (2). A Norwegian study found that among injuries with a fatal outcome, head trauma results in four of five fatalities, and bleeding is the next most frequent cause of death (3).

Blunt trauma to the pancreas is potentially life-threatening. Reports indicate that 75 – 100 % of pancreatic injuries in children are caused by blunt trauma to the abdomen, either due to force from a seat belt during a car accident, a fall or a bicycle handlebar injury (4, 5). The pancreas is pressed against the spinal column, resulting in compression and contusion of the tissues and in some cases injury to or a tear in the pancreatic duct (Fig. 1).
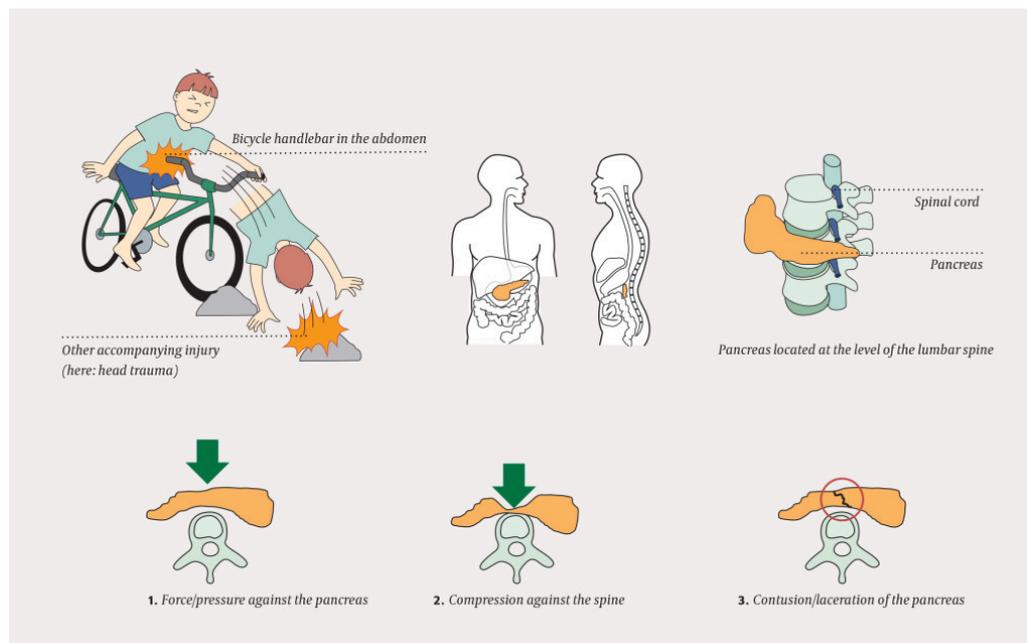

Figure 1 Pancreatic injury in children resulting from a bicycle handlebar accident. The pancreas is pressed against the spinal column, resulting in compression and contusion of the tissues and in some cases injury to or a tear in the pancreatic duct.

Pancreatic injury from blunt trauma can be difficult to diagnose, as the initial symptom profile may be diffuse. A high degree of clinical vigilance is needed. We therefore wanted to present updated information about diagnostics and treatment.

Evidence base

A literature search in the PubMed database using the Medical Subject Headings (MeSH) terms 'pancreas' and 'injuries' as sub-headings was performed on 20 October 2015 (Fig. 2). The search words were limited to pancreatic injuries and filtered for studies on humans (Humans, Child), age (birth–18 years), publication period (10 years) and language (Danish, English, Norwegian, Swedish). The search yielded 126 results. Supplementary free-text searches were performed to locate articles not containing MeSH terms by searching for the combinations 'pancreas OR pancreatic AND trauma OR injury OR injuries' (Fig. 2). After filtering for '10 years, Humans & Child: birth–18 years' and reviewing 384 articles, two were included in this study.
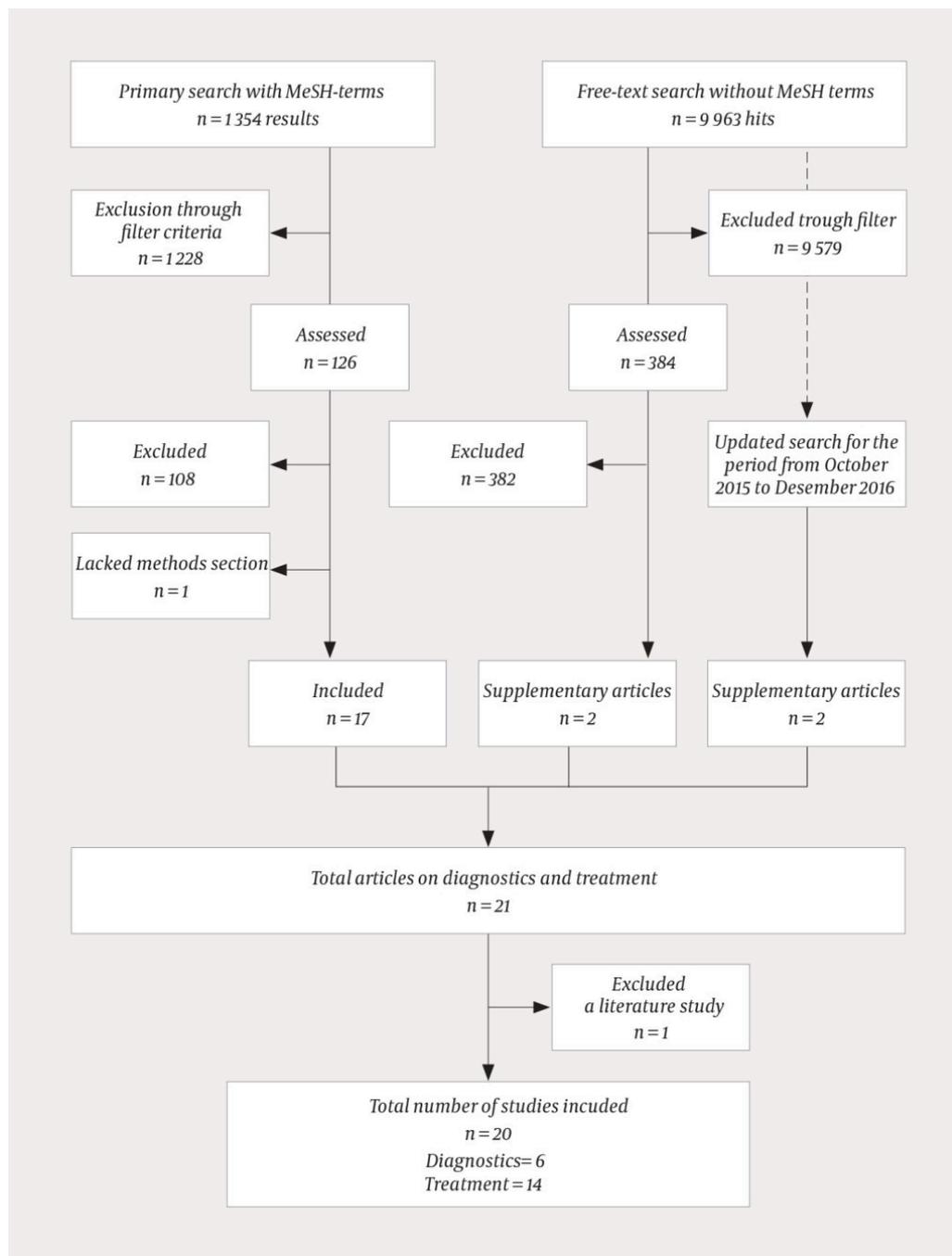
Figure 2 Flow chart of the literature searches and studies included

We assessed full-text articles on the diagnosis and/or treatment of blunt pancreatic injury in children. Studies with multiple organ injuries, in which pancreatic trauma was present and treatment was required, were included. Studies with fewer than five patients (case reports) and studies of penetrating injuries only were excluded.

In total, the searches resulted in a discretionary selection of 20 articles (Fig. 2). We excluded a pure literature study (6) and a literature study that lacked a methods section (7). A complementary search for the period from 20 October 2015 to 20 October 2016 resulted in the inclusion of two additional articles (8, 9) (Fig. 2). One of the literature studies (7) did not contain a methods section and was excluded, as it was not possible to perform and evaluate the search the authors had done. Another study (4) was excluded because it did not state whether the injury mechanism was blunt or penetrating. Of the final 20 articles included, six were related to diagnostics (10–15) and 14 (16 – 29) to treatment.

Incidence

Pancreatic injuries in children are rare. A study of 610 000 children with injuries showed that trauma to the pancreas comprised 0.3 % of the total (21). Corresponding figures for children are not available from Norway or Europe. Most of the blunt pancreatic injuries in children occur in the age group from 5 – 18 years (21, 27).

It can be difficult to accurately state the injury's grade of severity. A shared terminology for pancreatic trauma has been identified (30) and is currently used to define the extent of injury. Pancreatic injuries are scored in five categories (30), as shown in Table 1 and Figure 3. The two most important factors when scoring pancreatic injuries are whether the pancreatic duct is involved and whether the injury is located in the proximal section (pancreatic head) or the distal section (pancreatic tail).

Table 1

Injury scoring scale from the American Association for the Surgery of Trauma (30)

| Grade	Injury	Description
I	Hematoma	Minor contusion without duct injury
	Laceration	Superficial laceration without duct injury
II	Hematoma	Major contusion without duct injury or tissue loss
	Laceration	Major laceration without duct injury or tissue loss
III	Laceration	Distal transection or parenchymal injury with duct injury
IV	Laceration	Proximal transection or parenchymal injury involving ampulla
V	Laceration	Massive disruption of pancreatic head
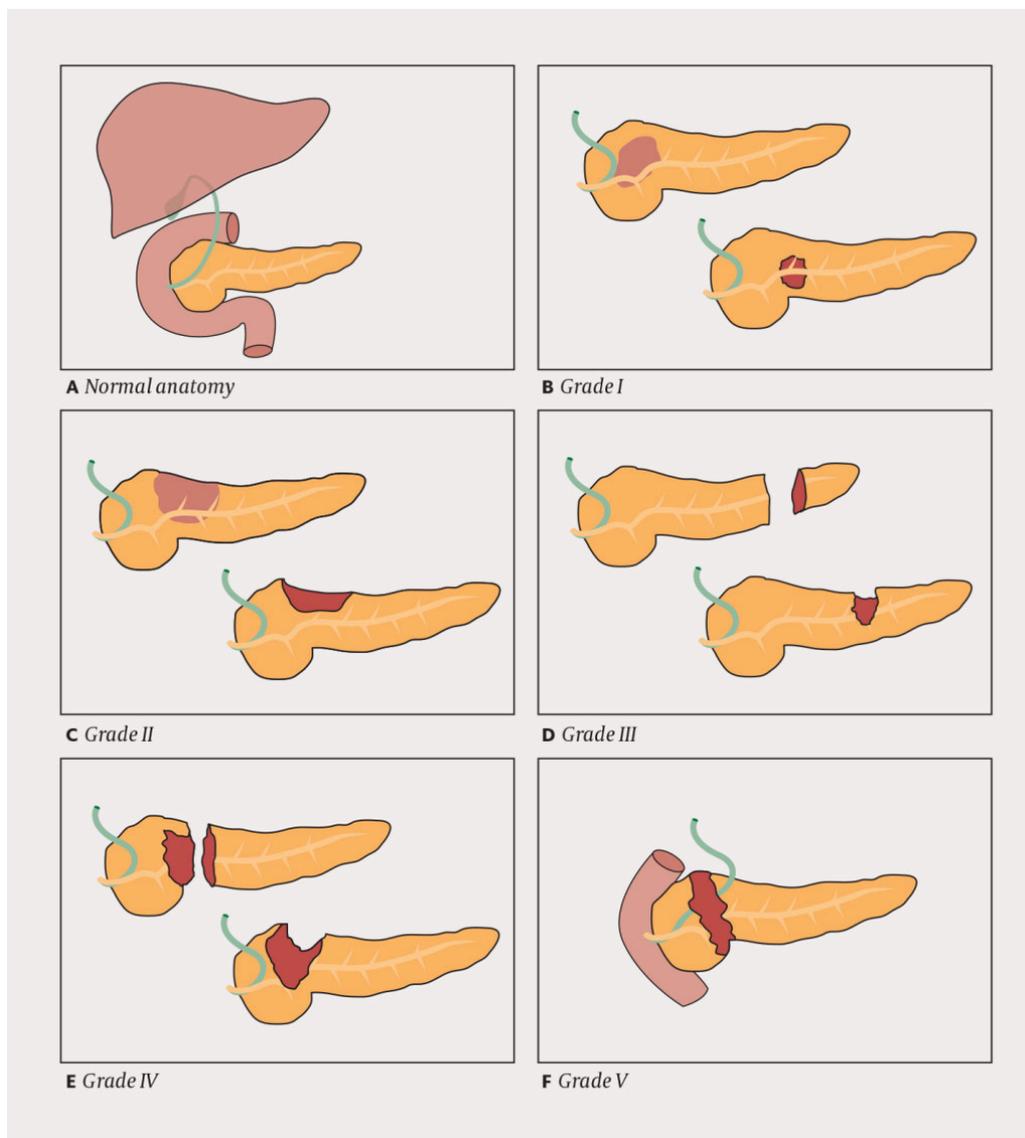
Figure 3 Illustration of injury grade, from the American Association for the Surgery of Trauma (30)

Pancreatic trauma includes a wide range of injuries, from simple contusion injuries (grade I-II) to complete rupture of the pancreatic duct and loss of parenchyma (grade III-V). Consequently, the level of injury also determines both the treatment and prognosis (31). Most injuries (about 85 %) are relatively limited, with little or no injury to the pancreatic duct and glandular tissue, or it is limited to the distal pancreas (grade I-III) (21). Grade I and II injuries may be described as traumatic pancreatitis, often accompanied by abdominal pain, an increase in lipase, and findings of contusions on imaging tests. Trauma to the pancreatic duct (grade III and higher) is the main determining factor in the level of severity, injury pathway, and prognosis.

Diagnostics

The injury mechanism and physiological impact guide the initial assessment and treatment of trauma patients. In cases of serious accident, the patient is assessed by a trauma team using trauma computed tomography (CT). In cases of a non-specific or isolated trauma mechanism, such as a bicycle handlebar

injury (Fig. 1), the initial symptoms are often non-specific, with vague or diffuse abdominal pains or a feeling of malaise. If presentation is delayed, the initial step is clinical observation based on the injury mechanism combined with clinical findings. When these are non-specific, there should be a low threshold for the use of diagnostic imaging.

Ultrasound is regarded as the first modality in stable patients when diagnostic imaging is needed for an orienting examination, especially with a view towards other organ injury (liver, spleen) or fluid collection in the pancreas. Use of CT or MRI must be considered when the injury mechanism, clinical findings and lipase values indicate potential pancreatic injury. We found six articles (10–15) that addressed diagnosis of pancreatic injury in children. Two studies were related to blood tests (11, 13) and four to diagnostic imaging (10, 12, 14, 15).

Blood tests

Several studies have assessed the significance of pancreatic enzymes for the early diagnosis and prognosis of pancreatic trauma (11, 13, 32); one of these is a systematic overview (32) and another is a multi-centre study related to prognostic value (11). Both serum amylase and lipase are regarded as sensitive enzyme markers for pancreatic cell damage, and are useful for diagnosing pancreatic trauma in children. Increased serum values are related to incidence of injury as compared to normal values in patients without this type of injury (32). S-amylase and s-lipase have the highest sensitivity when measured at least six hours following the time of injury (32), and are thus not reliable if measured less than two hours following the time of injury (11, 13). The optimal threshold value for the greatest diagnostic accuracy is not given. The large variation in increased enzyme values in the individual patient and across the injury scale make these poor markers for determining both level of severity and prognosis, related to the need for surgery, risk of death, and length of hospitalisation (11, 13). High maximum values of lipase are shown to be associated with a future risk of developing pseudocysts in children with pancreatic trauma, but this was found in only one smaller study (11).

Diagnostic imaging

Pancreatic injuries in children can be examined using ultrasound, CT scans, magnetic resonance cholangiopancreatography (MRCP) and endoscopic retrograde cholangiopancreatography (ERCP) (10, 12, 14, 15). Existing studies on the use of diagnostic imaging for pancreatic injury in children are small and retrospective.

Multidetector CT provides a good overview of many types of injuries, including most pancreatic injuries, and is often the first choice and standard within diagnostic imaging (33, 34). However, pancreatic injuries can remain undetected by CT scans, and several studies recommend using a combination of imaging methods, such as CT supported by MRCP and ERCP (33, 34). Newer methods such as secretin-enhanced MRCP may provide an even sounder diagnosis, but specific data on this in cases of pancreatic trauma have not been found, nor is this examination available at all hospitals.

ERCP has been shown to have the highest degree of sensitivity for detecting pancreatic duct injuries (9), but it requires an invasive procedure with accompanying risk, such as pancreatitis. This examination is the last resort for strictly diagnostic purposes, but it is indicated if injury to the pancreatic duct is suspected but cannot be confirmed using another modality. The method also plays a role in the treatment of pancreatic duct injury (9, 35, 36).

Treatment

Treatment of pancreatic trauma is determined by the total extent of the injury, the haemodynamic impact, and the incidence of concomitant injuries to the head, thorax, pancreas or extremities (31). When pancreatic injury is confirmed during a laparotomy in an unstable patient, drainage and transfer to a hospital with expertise in pancreatic surgery should be considered after other measures are taken to control the injury. Distal pancreatic resection may be performed at the same time as a necessary intervention in cases of spleen injury and the need for a splenectomy. No attempt should be made to treat other, more severe pancreatic injuries in the initial phase if the patient is in an unstable condition.

Treatment targeted at the pancreas can either be conservative (non-surgical) or surgical. In the 13 studies included here (16–27), (29), the number and type of pancreatic injury varied, and all studies with more than 100 patients were from the USA (Table 2). A Cochrane study from 2014 points to deficiencies in the current data on the choice of treatment (6).

Table 2

Treatment of pancreatic injury in children in the studies included

Author, year, country (ref.) Number	Grade	Treatment n (%)	Mortality n (%)	Morbidity n (%)
Juric, 2008, Croatia (23) 7	I-II	7 (100) non-surgical treatment	-	3 (43) in cases of non-surgical treatment
Vane, 2009, USA (29) 14	II-V	9 (64) operations 5 (36) non-surgical treatment	1 (7.1)	Not given
Houben, 2007, England (28) 15	II-IV	15 (100) non-surgical treatment (conservative)	-	2 (13) required endoscopic cyst drainage, one was performed later as an open cystogastronomy
Borkon, 2011, USA (17) 28	III-IV	25 (100) operations (15 distal pancreatectomy and 10 Roux-en-Y pancreaticojejunostomy)	1 (4)[1]	24% for both groups

Author, year, country (ref.)	Number	Grade	Treatment n (%)	Mortality n (%)	Morbidity n (%)
Cigdem, 2011, Turkey (18)	31	I-IV	6 (19) operations 25 (81) non-surgical treatment	0	0 in cases of surgery and 15 (60) in cases of non-surgical treatment
de Blaauw, 2008, Netherlands (20)	34	I-IV	3 (9) operations 31 (91) non-surgical treatment	0	2 (67) in cases of surgery and 14 (45) following non-surgical treatment
Wood, 2009, USA (27)	43	I-IV (25 ≥ grade II)	14 (56) operations 11 (44) non-surgical treatment	1 (4)	3 (21) in cases of surgery and 8 (73) in cases of non-surgical treatment
Beres, 2013, Canada/USA (16)	77	III-IV (n=39 ≥ III)	15 (38) operations 24 (62) non-surgical treatment	0	4 (27) in cases of surgery and 17 (74) following non-surgical treatment
Cuenca, 2012, USA (19)	79	I-V	24 (30) operations 55 (70) non-surgical treatment	10 (12.6)[1]	Not given
Paul, 2011, USA (26)	131	II-III (n=43)	20 (47) operations 23 (53) non-surgical treatment	0	9 (45) in cases of surgery and 8 (35) in cases of non-surgical treatment
Iqbal, 2014, USA (22)	167	II-III	57 (34) operations 15 (9) drainage tube inserted (57) non-surgical treatment	4 (2.4)	18 (32) in cases of surgery and 26 (27) in cases of non-surgical treatment
Mattix, 2007, USA (24)	173	I-V	43 (25) operations 130 (75) non-surgical treatment	4 (2.3)	Incomplete data
Mora, 2016, USA (25)	424	III-V	202 (48) operations 194 (46) non-surgical treatment	13 (3.1)	47 (23) in cases of surgery, 55 (28) in cases of non-surgical treatment and 13 (46) in cases of delayed surgery
			28 (6) delayed operations		Surgery (> 48 hours after admission to hospital)

Author, year, country (ref.) Number	Grade	Treatment n (%)	Mortality n (%)	Morbidity n (%)
Englum, 2016, USA (21) 674	I-V	160 (24) operations 514 (76) non-surgical treatment	36 (5)	30 (36) in cases of surgery 62 (24) in cases of non-surgical treatment

[1]Described as the need for reinterventions, repeat surgery, formation of fistulae or pseudocysts, other related complications during treatment.

Conservative treatment

About 75 – 85 % of children with pancreatic injuries receive non-surgical treatment, based on the grade of injury (6, 16, 21, 37). Almost all grade I injuries are treated conservatively without surgical interventions. As the grade of injury increases, reports vary regarding the success of conservative treatment, but conservative treatment is attempted and performed successfully at all injury grades.

Non-surgical treatment consists of close monitoring of the patient's vital signs, adequate pain relief and observation (21, 25, 31), and possibly treatment with total parenteral nutrition if the patient is unable to eat or must fast for other reasons. Initial monitoring of s-amylase and lipase levels, as well as repeated radiological examinations such as ultrasound, CT and MRCP, are performed as indicated.

ERCP involving insertion of a stent is regarded as a non-surgical treatment method (9, 20, 28, 35, 36), although this is an intervention which, among other things, is associated with an increased risk of pancreatitis. Stent treatment may reduce leakage of pancreatic secretions into the pancreatic cavity (in cases of pseudocyst or pancreatic fistula). Sequelae following ERCP may occur, e.g. strictures in the pancreatic duct, pancreatic fistula and fluid collection requiring drainage, and subsequent development of pseudocysts (20, 35). There are no relevant studies on whether somatostatin analogues (such as sandostatin) have a role in conservative treatment to reduce pancreatic secretions. These must therefore be assessed on an individual basis.

Percutaneous drainage of fluid collections may be appropriate if fluid collection is confirmed. Then it is important to investigate and exclude injury to the pancreatic duct if fluids collect during the clinical pathway. Several studies report that even more severe grades of injury can be managed conservatively, possibly with ERCP and insertion of a stent, but then a greater risk of complications and a longer hospitalisation can be expected.

In a study from Boston involving 131 children, 43 patients had a grade II or grade III injury. Among these, no difference was found between surgical and non-surgical treatment with regard to length of hospitalisation, complications and co-morbidity (27), but children who underwent surgery were more seriously injured and had trauma to multiple organ systems. However, another

study found that grade III injuries in the distal pancreas were best served with surgery, resulting in shorter hospitalisations and fewer complications (22). In up to half of the patients, grade III and IV injuries can be treated with early drainage, with or without ERCP and stent insertion. The risk of further interventions is greater with these measures, and future surgery will nonetheless often be necessary (7, 16, 22). Up to half of the children treated with observation alone will develop pseudocysts. Almost half of these can be treated with observation, and the pseudocyst will usually recede spontaneously (14, 38).

Surgical treatment

There is greater variation in the recommendations for injuries involving the pancreatic duct (grade III–V), and wide variation in practice is still reported for these injuries (8). If the patient does not show clinical improvement with drainage for grade III and IV injuries in the distal pancreas, this indicates a need for distal pancreatic resection. If there is a need for distal pancreatic resection in a stable patient with an intact spleen, spleen-preserving surgery should be performed. Interventions such as a pancreaticoduodenectomy (the Whippel procedure), central pancreaticojejunostomy, distal Roux-en-Y pancreaticojejunostomy (17) or a duodenum-preserving pancreatic head resection are described (39), but rarely indicated except in cases of extremely severe injury to the pancreatic head. There is a greater tendency to perform surgery on children with multiple injuries, and in such cases splenectomy is the most frequently performed simultaneous procedure (21). A severe injury grade and injuries located in the pancreatic head more often require surgical treatment (21).

Surgical treatment for grade III or more severe injuries was preferred as a final treatment of pancreatic injuries involving the pancreatic duct (7, 16, 17, 22, 24). The main argument in favour of surgical treatment is a shorter hospitalisation, less time until the patient can consume food again, and less need for total parenteral nutrition over a long period of time. Half of all children with severe pancreatic trauma (grade V) were treated conservatively in studies from the U.S., and no differences in the measured endpoints were found (21, 25). However, there was a significant difference in patient selection. This may be due in part to the fact that it is unclear what the indications are for surgery and resection in the individual patient. In patients who undergo surgery for another reason (spleen injury, intestinal perforation), there is probably a greater tendency to also perform a resection for a confirmed pancreatic duct injury. Isolated pancreatic injuries in children who are otherwise unaffected will generally undergo observation at first.

Complications such as pancreatic fistula also occur among patients who undergo surgery (22), and must therefore be taken into account in the choice of treatment method. Conservatively treated pancreatic duct injuries (grade ≤ III) have up to a 40 – 50 % incidence of pseudocyst during the clinical course. The large variation in approach to surgery or conservative treatment is based on a limited evidence base and a lack of prospective studies (8). Therefore, when choosing a treatment method, an assessment must be made regarding the injury grade of the pancreas together with other injuries in the pancreas or in

other organ systems, and the potential need for other surgery for such injury. Initially confirmed injury in a critically ill patient should be handled conservatively at first, and the patient should be transferred to a hospital with expertise in pancreatic surgery. Surgery can then be assessed during the clinical pathway based on the haemodynamics, overall injury scenario, and the surgery that is considered to be necessary.

Complications and mortality

The most common complications related to severe pancreatic trauma are the formation of pseudocysts and pancreatic fistulae (16, 22, 25, 31, 40). In addition, 10 – 30 % of patients develop secondary complications such as pneumonia, pleural effusion and intraabdominal abscesses following a pancreatic injury (6, 40). The studies showed either low or no mortality (22, 25, 41, 42). As a general rule, mortality is related to injuries in organs other than the pancreas, such as severe brain injury and multiple organ failure. This is consistent with the findings of a Norwegian study on causes of death resulting from fatal injuries in children (3).

Discussion

Pancreatic trauma resulting from abdominal injuries in children are less common than injuries to the spleen, liver and kidneys. However, children with pancreatic injuries often have injuries to other organs. The organs involved most frequently are the spleen (21 %), liver (11 %) and kidneys (6 %). The incidence is 0.6 – 9.5 % of all abdominal injuries (21, 24).

Pancreatic trauma with sequelae was last discussed in the Journal of the Norwegian Medical Association over 30 years ago (43). Some of the most significant changes in diagnostics and treatment are related to the use of medical imaging. Both CT and MRI scans are now more widely used and have better sensitivity over ultrasound. It is likely that more low-grade injuries are now diagnosed that previously would have been overlooked. There has been no systematic recording of such injuries in Norway. Published registry data from recent years are available only from national trauma registries in the USA (21, 25, 42).

Optimal diagnostics and treatment for the range of pancreatic injuries continue to be discussed, especially with regard to injuries to the pancreatic duct. This is due to a variety of factors: differences in incidence, different approaches between centres and regions, and the fact that pancreatic injury is rare and thus few formal studies of the topic have been conducted (3). Concomitant injuries in about 80 % of the children must also be taken into account when choosing a treatment method. Our study was limited to data from the literature of the last 10 years about an injury that is rare and where few centres have significant experience. Consultation with trauma centres and hospitals with diagnostic and therapeutic experience with the pancreas will therefore be necessary.

There is a widespread understanding that grade I and II pancreatic injuries can be treated conservatively (2) in almost all cases. For injuries involving the pancreatic duct (grade III–IV), there is a lack of consensus regarding the best treatment option. In patients whose extent of injury is otherwise limited, surgery will likely result more quickly in final and complete treatment. Of course surgery will be considered in a different light for patients with other severe, concomitant injuries, such as severe head or thorax trauma, in which a conservative approach is usually sought from the outset. Measured in endpoints such as length of hospitalisation and mortality, there is no significant difference in the short-term results between surgery and a conservative approach for these factors (21, 25). In this case, patient selection and the fact that complications occur in connection with both conservative and surgical treatment must be taken into account.

Main points

Blunt pancreatic injuries in children are rare, but can potentially be severe.

Such injuries may be difficult to diagnose, and both magnetic resonance cholangiopancreatography and endoscopic resonance cholangiopancreatography are relevant, in addition to CT scans.

For some patients with pancreatic duct trauma, stenting, drainage, and in some cases surgery are required, but most cases can be managed with observation.

Mortality is associated primarily with severe head trauma and multiple organ failure.

LITERATURE

1. Norton R, Kobusingye O. Injuries. N Engl J Med 2013; 368: 1723 - 30. [PubMed][CrossRef]

2. Notrica DM. Pediatric blunt abdominal trauma: current management. Curr Opin Crit Care 2015; 21: 531 - 7. [PubMed][CrossRef]

3. Søreide K, Krüger AJ, Ellingsen CL et al. Pediatric trauma deaths are predominated by severe head injuries during spring and summer. Scand J Trauma Resusc Emerg Med 2009; 17: 3. [PubMed][CrossRef]

4. Klimek PM, Lutz T, Stranzinger E et al. Handlebar injuries in children. Pediatr Surg Int 2013; 29: 269 - 73. [PubMed][CrossRef]

5. Dai LN, Chen CD, Lin XK et al. Abdominal injuries involving bicycle handlebars in 219 children: results of 8-year follow-up. Eur J Trauma Emerg Surg 2015; 41: 551 - 5. [PubMed][CrossRef]

6. Haugaard MV, Wettergren A, Hillingsø JG et al. Non-operative versus operative treatment for blunt pancreatic trauma in children. Cochrane Database Syst Rev 2014; 2: CD009746 [PubMed].. [PubMed]

7. Maeda K, Ono S, Baba K et al. Management of blunt pancreatic trauma in children. Pediatr Surg Int 2013; 29: 1019 - 22. [PubMed][CrossRef]

8. Naik-Mathuria B. Practice variability exists in the management of high-grade pediatric pancreatic trauma. Pediatr Surg Int 2016; 32: 789 - 94. [PubMed][CrossRef]

9. Keil R, Drabek J, Lochmannova J et al. What is the role of endoscopic retrograde cholangiopancreatography in assessing traumatic rupture of the pancreatic in children? Scand J Gastroenterol 2016; 51: 218 - 24. [PubMed][CrossRef]

10. Bosboom D, Braam AW, Blickman JG et al. The role of imaging studies in pancreatic injury due to blunt abdominal trauma in children. Eur J Radiol 2006; 59: 3 - 7. [PubMed][CrossRef]

11. Herman R, Guire KE, Burd RS et al. Utility of amylase and lipase as predictors of grade of injury or outcomes in pediatric patients with pancreatic trauma. J Pediatr Surg 2011; 46: 923 - 6. [PubMed][CrossRef]

12. Klin B, Abu-Kishk I, Jeroukhimov I et al. Blunt pancreatic trauma in children. Surg Today 2011; 41: 946 - 54. [PubMed][CrossRef]

13. Matsuno WC, Huang CJ, Garcia NM et al. Amylase and lipase measurements in paediatric patients with traumatic pancreatic injuries. Injury 2009; 40: 66 - 71. [PubMed][CrossRef]

14. Sheikh F, Fallon S, Bisset G et al. Image-guided prediction of pseudocyst formation in pediatric pancreatic trauma. J Surg Res 2015; 193: 513 - 8. [PubMed][CrossRef]

15. Sutherland I, Ledder O, Crameri J et al. Pancreatic trauma in children. Pediatr Surg Int 2010; 26: 1201 - 6. [PubMed][CrossRef]

16. Beres AL, Wales PW, Christison-Lagay ER et al. Non-operative management of high-grade pancreatic trauma: is it worth the wait? J Pediatr Surg 2013; 48: 1060 - 4. [PubMed][CrossRef]

17. Borkon MJ, Morrow SE, Koehler EA et al. Operative intervention for complete pancreatic transection in children sustaining blunt abdominal trauma: revisiting an organ salvage technique. Am Surg 2011; 77: 612 - 20 [PubMed].. [PubMed]

18. Cigdem MK, Senturk S, Onen A et al. Nonoperative management of pancreatic injuries in pediatric patients. Surg Today 2011; 41: 655 - 9. [PubMed][CrossRef]

19. Cuenca AG, Islam S. Pediatric pancreatic trauma: trending toward nonoperative management? Am Surg 2012; 78: 1204 - 10 [PubMed].. [PubMed]

20. de Blaauw I, Winkelhorst JT, Rieu PN et al. Pancreatic injury in children: good outcome of nonoperative treatment. J Pediatr Surg 2008; 43: 1640 - 3.

[PubMed][CrossRef]

21. Englum BR, Gulack BC, Rice HE et al. Management of blunt pancreatic trauma in children: Review of the National Trauma Data Bank. J Pediatr Surg 2016; 51: 1526 - 31. [PubMed][CrossRef]

22. Pancreatic Trauma in Children (PATCH) Study Group. Operative vs nonoperative management for blunt pancreatic transection in children: multi-institutional outcomes. J Am Coll Surg 2014; 218: 157 - 62. [PubMed][CrossRef]

23. Jurić I, Pogorelić Z, Biocić M et al. Management of blunt pancreatic trauma in children. Surg Today 2009; 39: 115 - 9. [PubMed][CrossRef]

24. Mattix KD, Tataria M, Holmes J et al. Pediatric pancreatic trauma: predictors of nonoperative management failure and associated outcomes. J Pediatr Surg 2007; 42: 340 - 4. [PubMed][CrossRef]

25. Mora MC, Wong KE, Friderici J et al. Operative vs Nonoperative Management of Pediatric Blunt Pancreatic Trauma: Evaluation of the National Trauma Data Bank. J Am Coll Surg 2016; 222: 977 - 82. [PubMed][CrossRef]

26. Paul MD, Mooney DP. The management of pancreatic injuries in children: operate or observe. J Pediatr Surg 2011; 46: 1140 - 3. [PubMed][CrossRef]

27. Wood JH, Partrick DA, Bruny JL et al. Operative vs nonoperative management of blunt pancreatic trauma in children. J Pediatr Surg 2010; 45: 401 - 6. [PubMed][CrossRef]

28. Houben CH, Ade-Ajayi N, Patel S et al. Traumatic pancreatic duct injury in children: minimally invasive approach to management. J Pediatr Surg 2007; 42: 629 - 35. [PubMed][CrossRef]

29. Vane DW, Kiankhooy A, Sartorelli KH et al. Initial resection of potentially viable tissue is not optimal treatment for grades II-IV pancreatic injuries. World J Surg 2009; 33: 221 - 7. [PubMed][CrossRef]

30. Moore EE, Cogbill TH, Malangoni MA et al. Organ injury scaling, II: Pancreas, duodenum, small bowel, colon, and rectum. J Trauma 1990; 30: 1427 - 9. [PubMed][CrossRef]

31. Søreide K. Pancreas injury: the good, the bad and the ugly. Injury 2015; 46: 827 - 9. [PubMed][CrossRef]

32. Mahajan A, Kadavigere R, Sripathi S et al. Utility of serum pancreatic enzyme levels in diagnosing blunt trauma to the pancreas: a prospective study with systematic review. Injury 2014; 45: 1384 - 93. [PubMed][CrossRef]

33. Browning JG, Wilkinson AG, Beattie T. Imaging paediatric blunt abdominal trauma in the emergency department: ultrasound versus computed tomography. Emerg Med J 2008; 25: 645 - 8. [PubMed][CrossRef]

34. Panda A, Kumar A, Gamanagatti S et al. Evaluation of diagnostic utility of multidetector computed tomography and magnetic resonance imaging in blunt pancreatic trauma: a prospective study. Acta Radiol 2015; 56: 387 - 96. [PubMed][CrossRef]

35. Björnsson B, Kullman E, Gasslander T et al. Early endoscopic treatment of blunt traumatic pancreatic injury. Scand J Gastroenterol 2015; 50: 1435 - 43. [PubMed][CrossRef]

36. Garvey EM, Haakinson DJ, McOmber M et al. Role of ERCP in pediatric blunt abdominal trauma: a case series at a level one pediatric trauma center. J Pediatr Surg 2015; 50: 335 - 8. [PubMed][CrossRef]

37. Valentino M, Galloni SS, Rimondi MR et al. Contrast-enhanced ultrasound in non-operative management of pancreatic injury in childhood. Pediatr Radiol 2006; 36: 558 - 60. [PubMed][CrossRef]

38. Aydogdu B, Arslan S, Zeytun H et al. Predicting pseudocyst formation following pancreatic trauma in pediatric patients. Pediatr Surg Int 2016; 32: 559 - 63. [PubMed][CrossRef]

39. Bredbeck BC, Moore EE, Barnett CC. Duodenum preserving pancreatic head resection (Beger procedure) for pancreatic trauma. J Trauma Acute Care Surg 2015; 78: 649 - 51. [PubMed][CrossRef]

40. Kao LS, Bulger EM, Parks DL et al. Predictors of morbidity after traumatic pancreatic injury. J Trauma 2003; 55: 898 - 905. [PubMed] [CrossRef]

41. Ho VP, Patel NJ, Bokhari F et al. Management of adult pancreatic injuries: A practice management guideline from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg 2017; 82: 185 - 99. [PubMed] [CrossRef]

42. Safavi A, Skarsgard ED, Rhee P et al. Trauma center variation in the management of pediatric patients with blunt abdominal solid organ injury: a national trauma data bank analysis. J Pediatr Surg 2016; 51: 499 - 502. [PubMed][CrossRef]

43. Brabrand K, Søreide JA. Traumatisk pankreaspseudocyste hos barn. Behandlet med ultralydveiledet aspirajon. Tidsskr Nor Laegeforen 1985; 105: 811 - 3 [PubMed].. [PubMed]