CHAPTER 7.

GENERAL DISCUSSION AND FUTURE PERSPECTIVES

The liver is the most commonly injured organ following abdominal trauma.[1,2] Following the results of this thesis nonoperative management, perihepatic packing and delayed direct repair of juxtahepatic venous injuries have reduced mortality associated with liver bleeding. In order to pursue the right management strategy for each individual patient, the surgeon treating a severely injured patient with a liver injury will rapidly have to make several critical decisions. Most liver injuries can be managed nonoperative and do not require a surgical intervention by explorative laparotomy. A minority of bleeding liver injuries requires surgical repair, and direct repair of visible bleeding vessels and leaking bile ducts is recommended to reduce the risk of intrahepatic complications. The optimal management of patients with serious liver injuries therefore is still debated.[16,17,18,19,20] During the last two decades a paradigm shift in the management of liver trauma has occurred, from operative management - repairing liver injuries - to nonoperative management. The introduction of intermittent inflow occlusion[3] facilitates direct repair of liver injuries, but high mortality was noted in operative management of the high grade liver injuries.[4,5,6,7] The observation that many non-therapeutic laparotomies were performed after the introduction of diagnostic peritoneal lavage[8], and the introduction of computed tomography for the purpose of preoperative diagnostics, has led to a more conservative approach, which resulted in with better outcomes.[9,10] However, advanced surgical and radiological techniques, improvement of surgical critical care and the concept of damage control surgery have also helped to increase survival in patients with a serious liver injury.[11] Various studies have shown an improved outcome both after nonoperative management and damage control surgery.[12,13,14,15]

The central theme of this thesis is how to assess patients with liver injury and how to select the best treatment: nonoperative management, definitive repair or damage control laparotomy. First the preoperative assessment of patients and selection of the optimal treatment will be discussed, then the surgical techniques and strategies to achieve hemostasis. Lastly the treatment of liver related complications will be discussed.

Preoperative assessment of patients and selection of optimal treatment

Various symptoms warrant surgery in patients with abdominal trauma: Haemodynamic instability, generalized peritonitis, worsening metabolic acidosis during resuscitation or CT findings showing associated intraabdominal injuries requiring surgical repair. The role and added value of preoperative computed tomography in patients with abdominal trauma with the abovementioned symptoms is unclear.

In the beginning of the previous century local tenderness and hemodynamic instability were used as indicators to perform an exploratory laparotomy.[5,21,22,23] In the mid-sixties a positive for blood DPL was also used as an indicator.[8] While DPL is very sensitive, a high rate of non-therapeutic laparotomies for solid organ injuries in patients with blunt abdominal trauma was noted. Current diagnostic imaging techniques used

are ultrasound (FAST) and CT scanning. CT scan of the abdomen is the optimal diagnostic method to aid in both the diagnosis and management of blunt hepatic trauma in hemodynamically stable patients[24] CT scanning is more specific than ultrasound, which does not predict the source of bleed, and is therefore essential for surgeons, who need to decide on nonoperative treatment of patients with blunt or penetrating solid organ injuries.[25,26] In this thesis only 10 % of patients selected for operative management had a preoperative CT scan showing injuries requiring surgical repair, the other 90 % presented with hemodynamic instability or generalized peritonitis and underwent surgery without preoperative computed tomography. In the literature hemodynamic instability and generalized peritonitis[27] after abdominal trauma is a level 1 recommendation for urgent laparatomy.[28] CT scanning greatly facilitates diagnosis and grading of solid organ injuries, but the main concern remains missing a hollow organ injury.[10,29,30,31]

Some authors recommend a preoperative computed tomography in all hemodynamically stable patients regardless of clinical findings such as generalized peritonitis.[32] We do not support this recommendation. A preoperative CT scan in a patient with peritonitis should be based on the surgeon's experience and preference for preoperative planning. In our experience 90 % of patients with a clinical indication for an urgent laparotomy did not have a preoperative CT scan. With this approach an acceptable 5% of the patients underwent unnecessary laparotomies.

Nonoperative management of severe blunt liver injuries is on the increase with a similar increment in failure and the need for a delayed laparotomy. Several authors have described hypotension on admission as a predictor of failing NOM. For this reason, NOM has been prompted with the caveat that patients must be hemodynamically stable.[33,34,35,36,37] In this study hypotension on arrival itself was not a predictive factor for failing NOM in patients who respond to resuscitation. Although encouraging results from pioneers treating selected hemodynamically unstable patients under hypotensive resuscitation[38], persistent hemodynamic instability warrants an urgent laparotomy. Nonoperative management of BLI should be considered irrespective of the grade of liver trauma. In our study liver related complications contributed to failure of NOM, but could not predict failure of NOM. Other authors reported no liver related failure of NOM.[39] The presence of associated intraabdominal and extraabodminal injuries do not render nonoperative management inapplicable for patients with a liver injury, although associated intraabdominal injuries (spleen) do contributed to failing NOM.

Nonoperative management of blunt solid organ injuries is widely accepted. Conversely, SNOM of penetrating solid organ injuries and penetrating liver injuries has not been widely practiced, but it use has evolved over the last two decades.[40,41,42,43,44,45,46,47,48,49,50] The use of CT scanning permits the missile tract to be outlined, and detects liver injuries for NOM, irrespective of the grade of injury.

Nevertheless, despite the modern imaging techniques, the level of accuracy and sensitivity for diagnosing bowel injuries following penetrating abdominal trauma remains a source of concern. The surgeon must appreciate the risks of NOM of penetrating liver injuries and possess the resources to address potential complications without delay. Contrary to blunt abdominal injury, successful NOM of penetrating abdominal injuries, with or without advanced CT technology present, is still largely based in the findings from serial clinical complications.

Surgical Technique & Strategy

Despite the high success rate of selective nonoperative management of liver injuries, an exploratory laparotomy is indicated in the majority (75%) of patients following penetrating abdominal trauma and minority (25%) of patients following blunt abdominal trauma.[38, 51,52] The liver is the most commonly injured organ following abdominal trauma and subsequently there is a considerable chance that the general surgeon will be confronted with an injured liver, when performing an exploratory laparotomy.[1,2] Early recognition of the magnitude of complex liver injuries, and excluding or treating perihepatic injuries is essential. Once inside the abdomen, the first priority is to achieve temporary hemostasis, evacuate blood, and eviscerate the bowel. With blunt trauma, begin with packing and with penetrating trauma eviscerate and determine where the bleeding is coming from.[53] When there is a significant liver injury pack the liver temporarily and rapidly assess the rest of the abdomen before focusing on the liver injury. In the following section, the surgical approach to a bleeding liver, the surgical strategy in patients with penetrating thoracoabdominal trauma and patients with a complex pattern of injuries will be discussed.

The options for initial hemorrhage control described in textbooks and instructed at courses are manual compression, temporary packing and inflow occlusion–Pringle maneuver.[54,55,56,57] Perihepatic packing does not control arterial bleeders. Ligation of visible vessels has been used to treat arterial bleeding from the liver, control of deep arterial intrahepatic bleeding is often very difficult to achieve.[58,59,60,61] Inflow occlusion described by Pringle, facilitates the diagnosis and surgical management of arterial and venous bleeding.[62,63] In this thesis the results of ligation of visible bleeding vessels in combination with or without inflow control was successful and limits the use of postoperative angiography and subsequent embolization.

Diffuse bleeding from a damaged or devitalized liver requires surgical treatment. Some authors advocate performing resections[33,64] but the high mortality rate led to discontinuation of this treatment in most centers.[65,66] In our experience non-anatomical hepatic resection or debridement was reserved as surgical treatment during re-look and return to the operating theatre for removal of packs. Resections should not be used not

as primary surgical tool to achieve hemostasis due to the risk of unexpected blood loss in an already uncompromised trauma patient.

An increased awareness of the need to institute damage control procedures in the unstable patient has most likely led to a higher incidence of patients who undergo liver packing. There is a desire to remove the liver packs as soon as possible, but the risk of septic complications[67,68] the cardiopulmonary benefits[69,70] and the risk of re-bleed requiring repeat liver packing have to be weighed against each other. The results of the retrospective study were incorporated in the prospective study and showed that the first re-look laparotomy should be performed only after 48 hours, creating a minimum risk of rebleeding and keeping risks of septic complications as low as possible.

When dark blood is flowing from behind the liver after inflow occlusion, a venous bleeding is highly suspected. Juxtahepatic venous injuries are uncommon, but tend to be highly lethal. Widely mentioned is the application of atriacaval shunts in the management of these injuries. Few authors report successful results on shunting[71,72] and others have reported successful direct repair of venous injuries without the necessity performing a sternotomy[73,74]. A safe surgical approach is starting out with damage control, containment by tamponade using packs, followed by direct repair, when feasible after resuscitation and after an experienced team has been mobilized.[75] When in the near future the availability of hybrid operating theatres will increase, more advanced techniques such as endovascular stenting of the juxtahepatic vena cava will be included in the trauma surgeon's toolbox. This will most probably again change the surgical approach to abdominal trauma.

Injuries of the abdomen and chest can be a double jeopardy for the trauma surgeon. Most patients with thoracoabdominal trauma are successfully managed by thorax drainage followed by laparotomy. About one-third of the patients will need a surgical intervention in both chest and abdomen.[76] In patients with penetrating thoracoabdominal injuries with suspicion of occult cardiac injury and acute abdomen, it remains unresolved whether to have a two team approach, with one managing the chest and the other the abdomen. Furthermore, it is unclear which cavity should be managed in the first instance if there is only one surgeon. Any intraabdominal bleeding should take precedence but if, this is not encountered, a cardiac reason for the shock should be considered and a SPW done.[77]

A trauma operation follows a generic sequence of reproducible steps – access to abdomen, control of bleeding, prevent contamination, define injury pattern, urgency and time for repair, and physiological impact - followed by a strategic decision; definitive repair or damage control surgery.[78] Evidence that supports safety and efficacy of DCS compared with traditional laparotomy is supported by Class 2 and 3 level of evidence.[11,79,80,81,82,83,84,85,86] While an increase in incidence of patients who undergo damage control surgery has been noted, we should be aware of the increase in morbidity in

patients who unnecessarily undergo a damage control laparotomy. Despite reports of increased survival after the introduction of damage control surgery and implementation of damage control strategies in the field of emergency surgery [87,88,89] few authors conclude that evidence that supports the safety and efficacy of damage control is limited.[90] They call for the need of randomized controlled trials. An RCT would be confronted with the same dilemma, at first overuse of DCS in patients who could also tolerate definitive repair (DR), or vice versa an increase in mortality or morbidity in patients who are selected for DR. Approval of such RCTs by a Human Research Ethics Committee would not be granted. Currently the indication for DCS is dictated by the patient's physiologic behavior, the presence or absence of major liver injuries and vascular injuries, and concomitant injuries.

Angiography and embolization

Hepatic angiography is a useful addition to perihepatic packing or nonoperative management.[91,92,93,94] Although mortality related to angioembolization is reported to be low, concern has been expressed about the considerable morbidity.[15,95,96] Indications for angiography in abdominal trauma patients vary among institutions, but often include the presence of contrast blush on CT scans and patients who have required multiple blood transfusion. A contrast blush on a CT scan is considered a significant sign of bleeding, and should be followed immediately by angiography and possible embolization, despite the potential liver related sequels. Other researchers describe that 50% of patients with a contrast blush required an intervention, and hypotension on arrival. Severe abdominal trauma and a blush diameter of 1,5 cm or greater predicted the need for intervention.[97]

The role of postoperative angiography described in this thesis is limited. This is owing to the fact that, an active surgical management policy with ligation of visible vessels, rendered early postoperative angiography rarely necessary. In this study we did not perform routine angiography either. This adjunct diagnostic tool was used only on indication. Embolising a blush seen on a routine computed tomography should be related to clinical and radiological signs (blush diameter > 1,5 cm)[94]. Furthermore physicians need to recognize that an angiography is not a benign procedure - contrast nephropathy and risk of acute renal failure - especially in a multiple injured, postoperative critically ill patient admitted for secondary resuscitation in a surgical intensive care or high care unit. In our studies an early postoperative angiography was performed in only one of the 183 patients with penetrating liver injuries. The angiography was performed after a Sengstaken-Blakemore balloon was used to tamponade the wound tract, without signs of intravenous contrast extravasation (IVCE). This alternative technique has been presented as a successful treatment to control liver hemorrhage by several authors.[98,99]

Liver related complications

Biliary leakage and delayed bleeding following to blunt or penetrating hepatic trauma and severe damage to the intrahepatic parenchyma remain challenging problems. Delayed complications can occur days to weeks after trauma and they include delayed vascular and biliary complications, which can mostly be treated safely with less invasive techniques than laparotomy.[38,100,101,102]

Post traumatic hepatic artery pseudo aneurysm is an uncommon delayed complication. Pseudo aneurysm detected by CT should be treated as early as possible,[10,103] since occasionally hepatic artery pseudo aneurysms can become symptomatic.[93,96,104] In this thesis all six patients with pseudo aneurysm presented with symptoms (a fall in hemoglobin serum level (n=1), drainage of fresh blood via percutaneous drain(n=2) and hemobilia (n=3)) and were treated successfully with embolization. A follow up CT scan in this study population was not included as part of the protocol. Nevertheless a follow up CT scan in a "young" trauma population for a rarely seen, but potentially lethal complication is a topic of debate. The high number needed to treat and negative effects of radiation exposure are matters of concern. Clinical examination and follow up might be the preferred method.

Biliary leakage following liver trauma is a significant problem. Endoscopic retrograde cholangiography (ERC), biliary sphincterotomy and temporary internal stenting represent a safe and effective strategy for management of bile leaks following both blunt and penetrating trauma. ERC with internal drainage of complicated bile leaks has proven successful.[36,37,105,106,107,108] The timing of the ERC has been open to debate with some authors suggesting that this should be done as soon as the bile leak is evident.[109] This, however, does not take into account the natural history of a bile leak after severe trauma in which spontaneous resolution is the norm, irrespective of the mechanism, provided there is adequate drainage.[12,109] Minor bile leaks usually resolve with conservative management alone. Internal drainage should be considered when external drainage of bile is more than 400 ml per day or when the bile leakage has persisted beyond 14 days (this thesis).

Nonoperative Management of hemodynamically stable patients following blunt and penetrating hepatic trauma is safe in adequately selected patients. Use of damage control techniques is recommended in patients with a major hepatic bleeding or in patients with a minor liver injury with associated vascular injury and before the onset of metabolic failure. As a result of improved survival following severe hepatic parenchymal damage an increase in intrahepatic vascular and biliary complications has become evident. Many of these complications can be prevented by surgical ligation if a laparotomy is warranted, or can be managed by less invasive, percutaneous techniques in the acute (vascular) or secondary (biliary) stage.

Future perspectives. Trauma is a global problem, and carries a high price that is paid by individuals, communities, and nations. The liver is the most frequently injured intra-

abdominal organ following trauma, although the incidence of patients with a severe bleeding liver injury is low. Clinical suspicion, decision making, repeated clinical examination, and surgical experience play a crucial role in the management and outcome of patients with severe liver injuries. However, most of the world's population does not have direct access to such high level trauma centers and first class operating and surgical critical care facillities.[110] Further research should therefore not only focus on the role and use of advanced techniques, such as preoperative computed tomography, angiography and embolization, advanced endoscopic and endovascular techniques. Other more easily accessible tools that are also of influence on mortality and morbidity of trauma patients, should be explored, especially for the less well equipped countries and hospitals.

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