



Angioembolisatsiooni roll maksa traumaatiliste vigastuste korral

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2022 A.

Sissejuhatus

- ▶ Maks on **kõige sagedamini** traumeeritav organ* tõmbi trauma korral (või ikka põrn?)
- ▶ Maksakoe „devaskularisatsiooni“ peale mõeldi juba aastast 1950
- ▶ **Suremus** peale MT paranes **50% 1970 → 10-20 % tänapäeval** eelkõige tänu
 - ▶ Piltidiagnostika evolutsiooni
 - ▶ TR (*Trauma resuscitation*)
 - ▶ MTP (*Massive transfusion protocols*)
 - ▶ *Damage Control Surgery* (k.a maksa „pakkimine“)
 - ▶ NOM (*nonoperative management*)
 - ▶ Jälgimisvõimaluste paranemine
- ▶ Maksa roll inimese homöostaasis keeruline
- ▶ AE uurimiseks vajalikud eelkõige suured prospektiivsed uuringud, selliseid tänapäeval veel ei ole

Maksa trauma = hepatic trauma = HT = MT
Angioembolisatsioon = Angioembolization = AE

Maksa funktsioonid

- ▶ Maks praegu „asendamatut“ organ
- ▶ “Why so difficult [to treat]?”

Functions of the Liver

Detoxification:

- Drugs/Alcohol
- Fatty acids
- Steroid hormones
- Ammonia → Urea
- Environmental toxins/allergens

Production of Cholesterol:

- Precursor to sex hormones, Vitamin D

Storage of Micronutrients:

- Minerals: Copper, Zinc, Magnesium, Iron
- Vitamins: Vitamin A, D, E, K, B12

Metabolism:

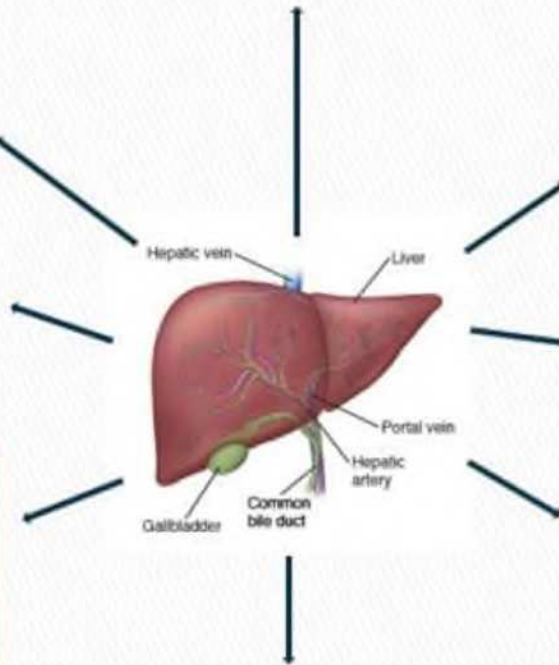
- Conversion of T4 → T3
- Detoxification of fat

Blood Sugar Balance:

- Storage of glycogen

Immune System:

- Contains viruses and pathogens
- Maintenance of the hepatic and portal vein immune system



Production of Bile:

- Needed for digestion
- GI anti-microbial

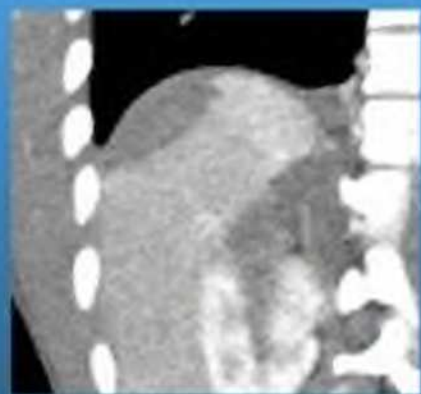
Protein Synthesis:

- Blood clotting (prothrombin)
- Cholesterol transport (lipoproteins)
- Immune Function (globulins)
- Oncotic pressure (albumin)
- Copper bioavailability (ceruloplasmin)

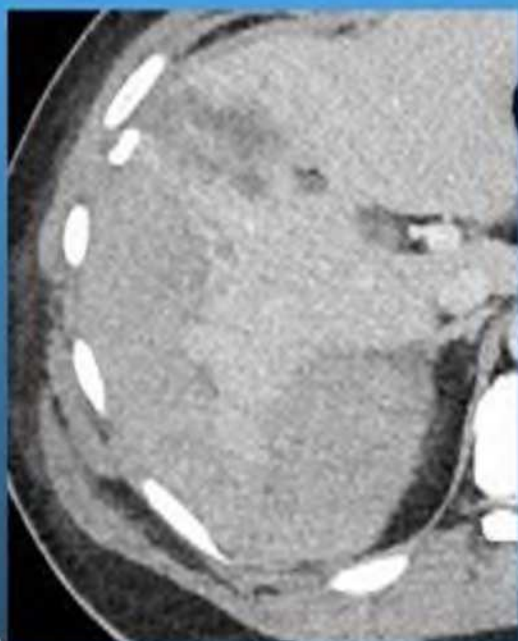
Grade 1



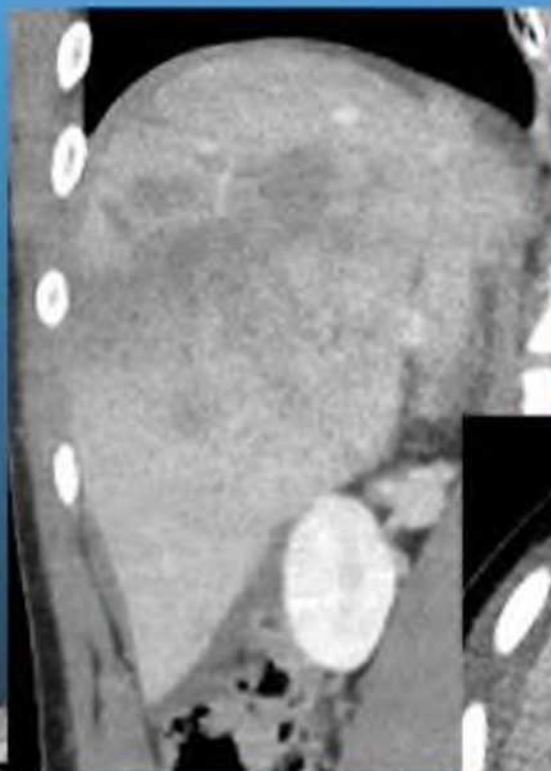
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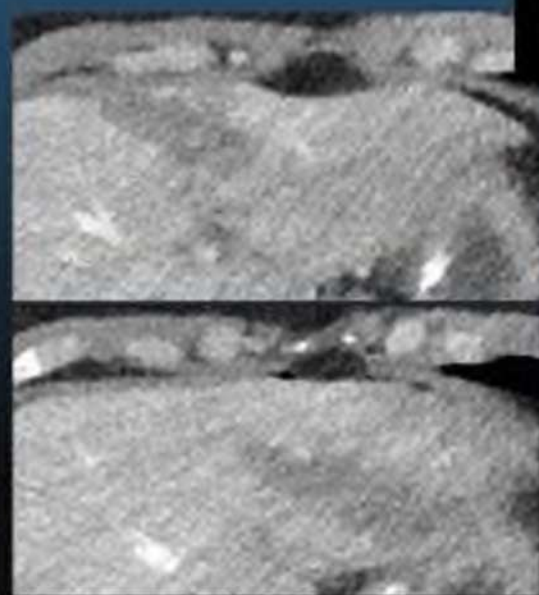
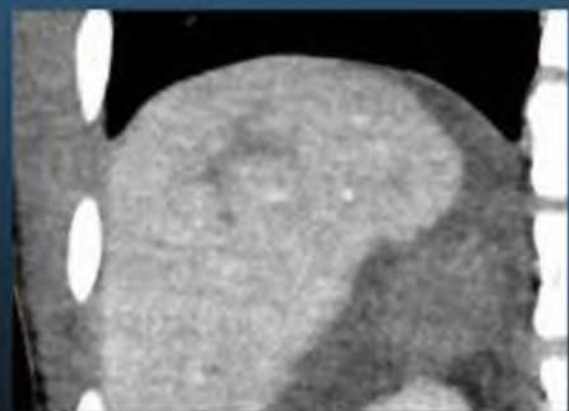
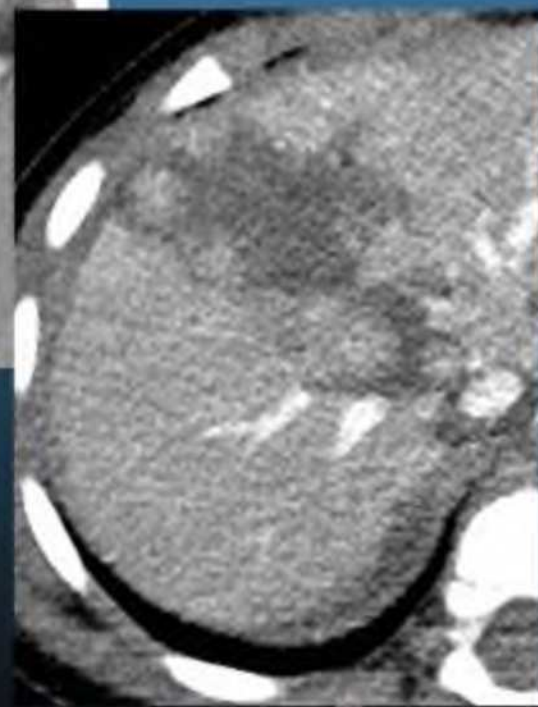
Grade 3



Grade 4



Grade 5



(examples from different patients)

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1. AAST MT klassifikatsioon

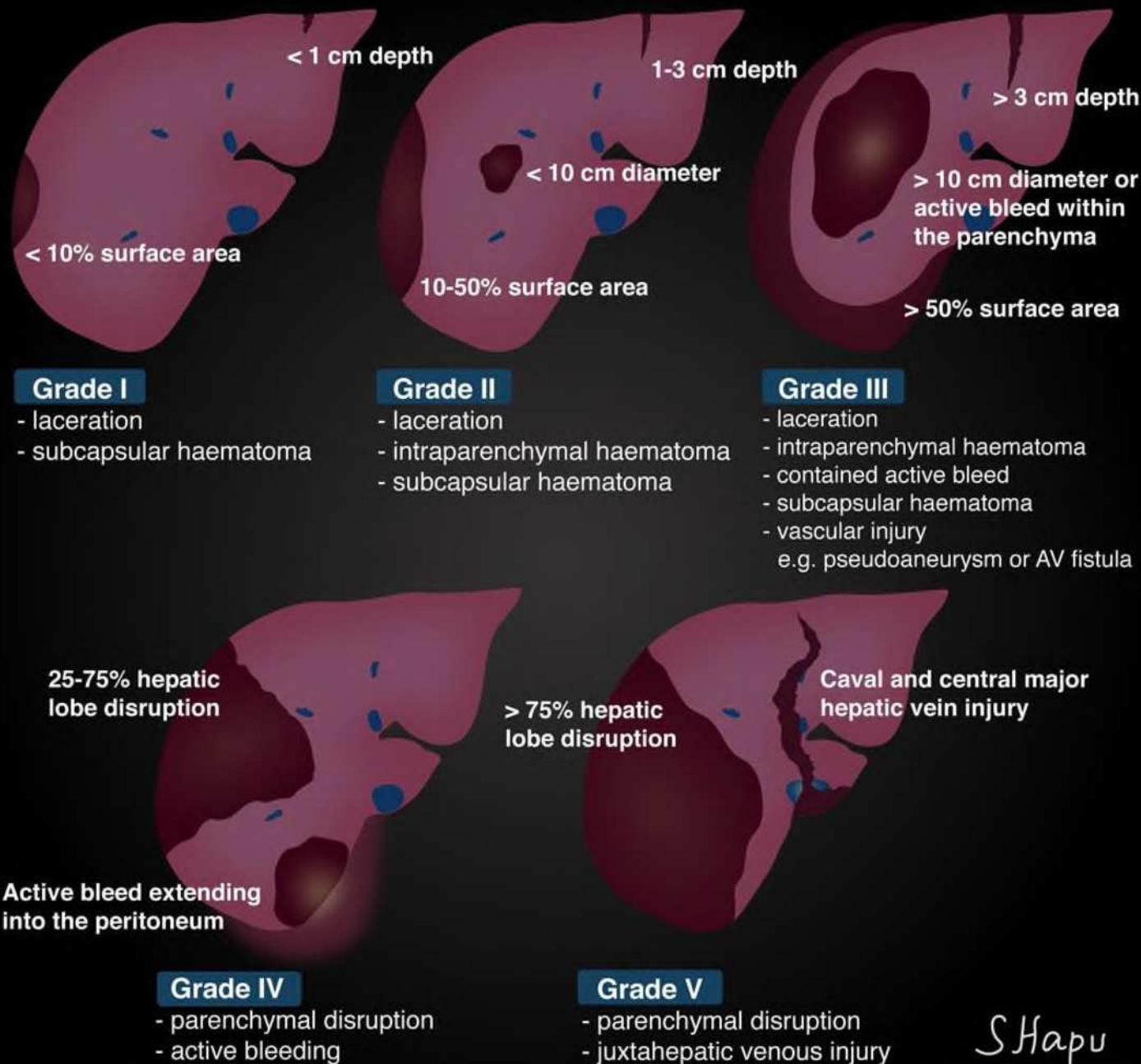
Table 1

American Association for the Surgery of Trauma 2018 update on hepatic injury grading.

AAST Liver Injury Scale—2018 Update¹

Grade	Associated Findings
1	- Subcapsular hematoma <10% surface area - Parenchymal laceration <1 cm in depth - Capsular tear identified intraoperatively
2	- Subcapsular hematoma 10–50% surface area - Intraparenchymal hemorrhage <10 cm in diameter - Laceration 1–3 cm in depth
3	- Subcapsular hematoma >50% surface area - Ruptured subcapsular or parenchymal hematoma - Intraparenchymal hemorrhage >10 cm in diameter - Laceration >3 cm in depth
4	25–75% lobar parenchymal disruption - Active hepatic hemorrhage with extension into the peritoneum
5	>75% lobar parenchymal disruption - Juxtahepatic venous injury involving retrohepatic vena cava and central major hepatic veins

¹ Low grade hepatic injury.



*Advance one grade for each additional injury upto grade III.

Clinical outcomes of non-operative management and clinical observation in non-angioembolised hepatic trauma: A systematic review of the literature

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ABSTRACT

Purpose: Liver is the most frequently injured organ in abdominal trauma. Today non-operative management (NOM) is considered as the standard of care in hemodynamically stable patients, with or without the adjunct of angioembolisation (AE). This systematic review assesses the incidence of complications in patients who sustained liver injuries and were treated with simple clinical observation. Given the differences in indications of treatment and severity of liver trauma and acknowledging the limitations of this study, an analysis of the results has been done in reference to the complications in patients who were treated with AE.

Methods: A systematic literature review searched “liver trauma”, “hepatic trauma”, “conservative management”, “non operative management” on MEDLINE (via PubMed), Cochrane Central Register of Controlled Trials databases, EMBASE, and Google Scholar, to identify studies published on the conservative management of traumatic liver injuries between January 1990 and June 2020. Patients with traumatic liver injuries (blunt and penetrating) treated by NOM, described at least one outcome of interests and provided morbidity outcomes from NOM were included in this study. Studies reported the outcome of NOM without separating liver from other solid organs; studies reported NOM complications together with those post-intervention; case reports; studies including less than 5 cases; studies not written in English; and studies including patients who had NOM with AE as primary management were excluded. Efficacy of NOM and overall morbidity and mortality were assessed, the specific causes of morbidity were investigated, and the American Association for the Surgery of Trauma classification was used in all the studies analysed. Statistical significance has been calculated using the Chi-square test.

Results: A total of 19 studies qualified for inclusion criteria were in this review. The NOM success rate ranged from 85% to 99%. The most commonly reported complications were hepatic collection (3.1%), followed by bile leak (1.5%), with variability between the studies. Other complications included hepatic haematoma, bleeding, fistula, pseudoaneurysm, compartment syndrome, peritonitis, and gallbladder ischemia, all with an incidence below 1%.

Conclusion: NOM with simple clinical observation showed an overall low incidence of complications, but higher for bile leak and collections. In patients with grade III and above injuries, the incidence of bile leak, collections and compartment syndrome did not show a statistically significant difference with the AE group. However, the latter result is limited by the small number of studies available and it requires further investigations.

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2. Esialgne otsus: NOM v   OM?

3. Mitte kõik veritsused on sarnased

- CT sensitiivsus arteriaalse verejooksu tuvastamisel MT korral **75-90%**
 - teiste uuringute põhjal 83% sensitiivne ja 75% spetsiifiline
- Tavaliselt kui AE ei anna oodatud tulemust on tegemist **venoosse veritsusega**.
- **Red flags:**
 - Kõrge energiaga trauma
 - Jätkuv verejooks peale tehniliselt õnnestunud AEi
- Venoosne vigastus raskesti diagnoositav angiograafias, parem multifaasiline CT uuring.
- Venoosse veritsuse korral sageli vajalikud
 - maksa pakkimine
 - transhepaatiline venoosne stentimine
 - nt Retrohepaatilise vena vava vigastuse korral
- Sellised veritsused ongi põhjuseks, miks AE võiks osutada ebaefektiivseks
- **2017 guidelines:** NOMi võib rakendada iga MT korral, niikauma kui pt. on stabiilne või stabiliseeritud, peritoniiditunnusteta, teiste IA vigastusteta mis vajavad kirurgiat

4.1 Tavalised AE näidustused

- ▶ Kasutatakse koos NOM'iga
 - ▶ kui pt. on hemodünaamiliselt stabiilne *
 - ▶ teised laparotoomia näidustused puuduvad
 - ▶ CT alusel on olemas ***contrast blush***



Reevaluation of Hepatic Angioembolization for Trauma in Stable Patients: Weighing the Risk



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BACKGROUND: Angioembolization (AE) is recommended for extravasation from liver injury on CT. Data supporting AE are limited to retrospective series that have found low mortality but high morbidity. These studies did not focus on stable patients. We hypothesized that AE is associated with increased complications without improving mortality in stable patients.

STUDY DESIGN: We queried the 2016 Trauma Quality Improvement Project database for patients with grade III or higher liver injury (Organ Injury Score ≥ 3), blunt mechanism, with stable vitals (systolic blood pressure ≥ 90 mmHg and heart rate of 50 to 110 beats/min). Exclusion criteria were nonhepatic intra-abdominal or pelvic injury (Organ Injury Score ≥ 3), laparotomy less than 6 hours, and AE implementation more than 24 hours. Patients were matched 1:2 (AE to non-AE) on age, sex, Injury Severity Score, liver Organ Injury Score, arrival systolic blood pressure and heart rate, and transfusion in the first 4 hours using propensity score logistic modeling. Primary outcomes were in-hospital mortality, length of stay, transfusion, hepatic resection, interventional radiology drainage, and endoscopic procedure.

RESULTS: There were 1,939 patients who met criteria, with 116 (6%) undergoing hepatic AE. Median time to embolization was 3.3 hours. After successfully matching on all variables, groups did not differ with respect to mortality (5.4% vs 3.2%; $p = 0.5$, AE vs non-AE, respectively) or transfusion at 4 to 24 hours (4.4% vs 7.5%; $p = 0.4$). A larger percentage of the AE group underwent interventional radiology drainage (13.3% vs 2.2%; $p < 0.001$), with more ICU days (4 vs 3 days; $p = 0.005$) and longer length of stay (10 vs 6 days; $p < 0.001$).

CONCLUSIONS: Hepatic AE was associated with increased morbidity without improving mortality, suggesting the benefits of AE do not outweigh the risks in stable liver injury. Observing these patients is likely a more prudent approach. (J Am Coll Surg 2020;231:123–132. © 2020 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

4.2 Näidustused: peale laparotoomiat

Persisteeriv **arteriaalne verejooks** peale laparotoomiat

- venoosse verejooksu korral ei pruugi AE olla efektiivne
- diagnostikas kasutatakse CT
- **diifdiagnoosiks oluline efektiivne maksa pakkimine op. ajal**
 - AE ei ole maksa pakkimise substituu

Adjunctive use of hepatic angioembolization following hemorrhage control laparotomy

J Trauma Acute Care Surg
Volume 88, Number 5

Matsushima et al.

BACKGROUND:	Severe liver injuries pose a challenge to trauma surgeons. While the use of hepatic angioembolization (HAE) has been evaluated as a component of the nonoperative management of liver injury, little is known about the efficacy of postoperative HAE in patients who require hemorrhage control laparotomy (HCL) for liver injury. The purpose of this study is to evaluate the impact of HAE following HCL on patient survival.
METHODS:	This is a retrospective cohort study using the American College of Surgeons Trauma Quality Improvement Program database from January 2013 to December 2014. In propensity score matched (2:1) patients who underwent HCL-only or HCL + HAE, the impact of adjunctive use of HAE on patient survival was examined with the Cox proportional hazards regression analysis adjusting for transfusion requirement within 4 hours. We also performed a subgroup analysis in patients without severe traumatic brain injury (Abbreviated Injury Scale head ≤ 3).
RESULTS:	A total of 1,675 patients met our inclusion criteria. Of those, 75 (4.5%) patients underwent HAE after HCL (median hours to HAE, 5 hours after admission). In 225 propensity score-matched patients, the use of HAE following HCL was significantly associated with improved 24-hour mortality , but not in-hospital mortality. In the subgroup of patients without severe traumatic brain injury ($n = 189$), we observed significant survival benefits (24-hour and in-hospital mortality) associated with the adjunctive use of HAE.
CONCLUSION:	The results of our study suggest that the adjunctive use of HAE might improve survival of patients who require HCL for liver injury . Further prospective study to determine the indication for postoperative HAE is still warranted. (<i>J Trauma Acute Care Surg</i> . 2020;88: 636–643. Copyright © 2020 Wolters Kluwer Health, Inc. All rights reserved.)
LEVEL OF EVIDENCE:	Therapeutic study, level III.
KEY WORDS:	Liver injury; angioembolization; adjunctive use; hemorrhage control surgery.

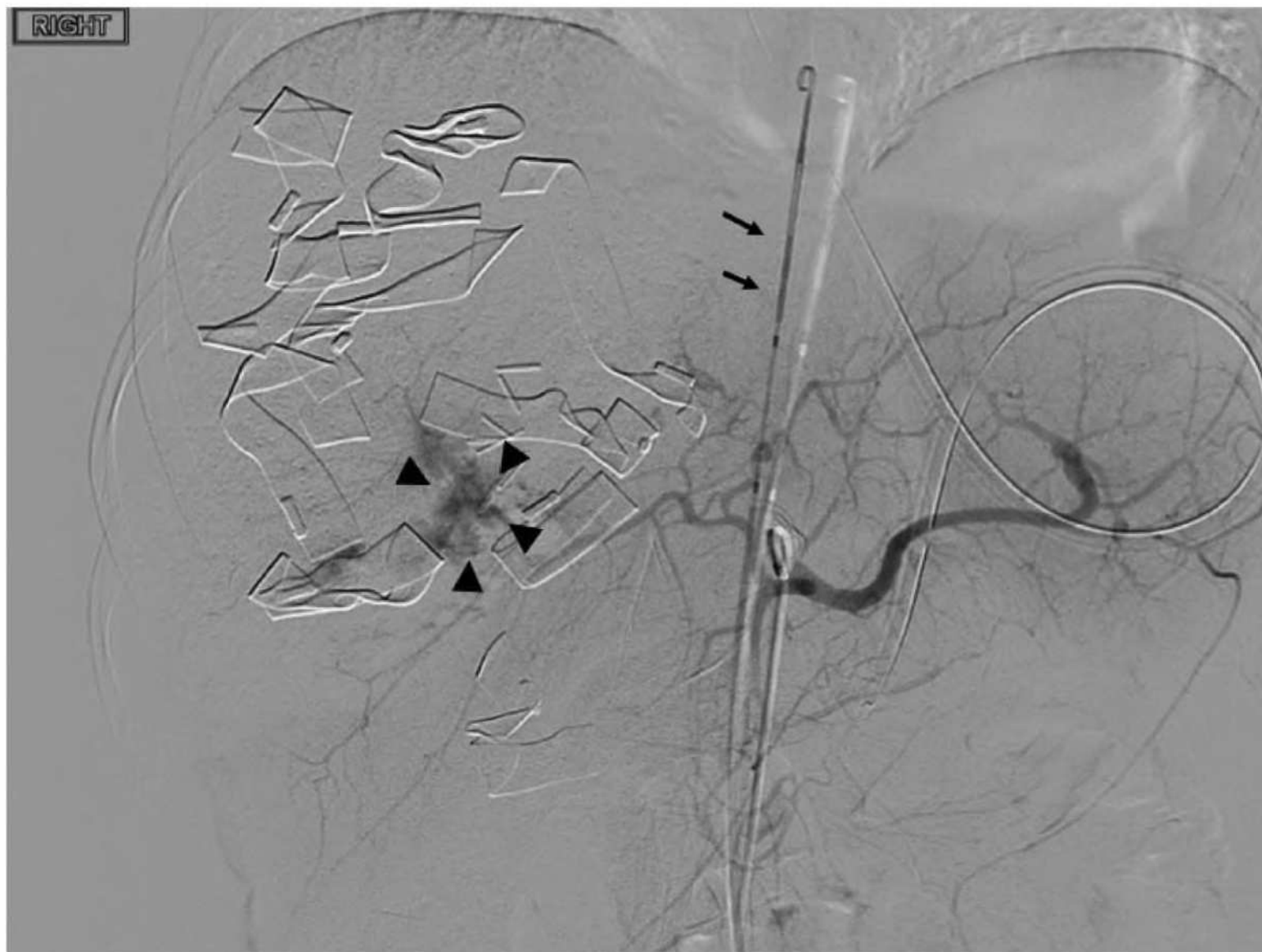


Figure 1. HAE following HCL. A case with Grade V liver injury which required HCL with non-anatomical liver resection and perihepatic packing. HAE was performed immediately after HCL in the hybrid OR. Active contrast extravasation was identified (arrowheads), then gel-form embolization was performed in the right hepatic artery. Of note, a REBOA catheter had been placed in Zone I (arrows). REBOA, resuscitative endovascular balloon occlusion of the aorta.

4.3 Näidustused: programmeeritud erakorraline

Planeeritud AE pre- või postop

- nt. *transient responders to resuscitation*
- **nendel, kellel laparotoomia teostatud teistel põhjustel**
- otsustamine situatsioonipõhine ning koostöös kirurgidega

4.4 Näidustuste kokkuvõte

1. Klassikalised näidustused:

- ▶ **koos NOM'iga**
- ▶ hemodünaamiliselt stabiilne
- ▶ teised laparotoomia näidustused puuduvad
- CT alusel on olemas *contrast blush*

2. **Persisteeriv arteriaalne verejooks peale laparotoomiat**

- Venosse verejooksu korral ei pruugi AE olla efektiivne
- Difdiagnoosiks oluline efektiivne maksa pakkimine op. ajal.
 - AE ei ole maksa pakkimise substituu

3. **Planeeritud AE** pre- või postop

- Nt. transient responders to resuscitation
- Need, kellel laparotoomia teostatud teistel põhjustel
- Otsustamine situatsioonipõhine ning koostöös kirurgidega

4. Korduv **verejooks peale edukat AEi** (5-12% juhtudest)

- ▶ **pt. peab olema stabiilne**

5. Pakutud ka AE IV ja V staadiumi vigastuste korral ilma verejooksuta

- **33% patsientidest blush on CT ei korreleeru angiograafia leiuga**
 - põrna puhul on see 17%

“Why so difficult [to treat]?”

- Tänapäeval maksa AE veel suhteliselt halvasti uuritud
- ▶ **Milline on edukas protseduur?**
 - Verejooksu peatamine?
 - Transfusioonivajaduse puudus?
 - Ravipäevade arv intensiivravi palatis?
 - maksa düsfunktsiooni tase?
- Võrreldes teiste organitega:
 - AE edukus põrna vigastuse korral u 93%
 - AE edukus neeru vigastuse korral u 96%, kliiniline 91%
 - AE edukus maksa vigastuse korral u 94%, **kliiniline edukus 68-87%**
- Maksa trauma käsitlemine ja tagajärjed sõltuvad
 - organi funktsiooni tasemest
 - koagulatsiooni süsteemi funktsioonist enne ja peale traumasid
 - verekaotusest
 - verekaotuse kompenseerimise strateegiast

Maksa iseärasused

- Arvestades verevarustuse anatoomiat maksas võivad veritseda
 - **arteriaalne** süsteem
 - **venoosne** süsteem
 - **maksa veenid**
 - mitu süsteemi korraga
- Oluline teada, et **hepatotsüüdid saavad suurema osa hapnikust maksa arterist**
 - Portaalne vereringe moodustab u 2/3 maksa vereringest kuid kannab < 50% hapnikust
- Verejooksu etioloogiast sõltub ravitaktika
 - Operatsioon
 - parandamine/reseksioon
 - pakkimine
 - AE
- **AE edukus maksa trauma korral madalam kui teiste soliidsete organite korral**

4. AEs kasutatavad materjalid

- **Gelfoam**

- kehas **imenduv**
- **toimiseks vajalik funktsioneeriv koag. süsteem**
 - Sügava koagulopaatia, atsidoosi korral ei pruugi töötada
- Tõusnud infektsiooni risk

- **Mikropartiklid**

- Suurus 100 - 1200 µm
- Mikrosfääride materjaliks polyvinyl alcohol, trisacryl jt
- Tavaliselt kasutatav **permanentseks väikeste veresoonte oklusiooniks**
 - väikeste veresoonte oklusioon → nekrootilisi, infektsioosid, düsfunktsiooni tüsistuste tõenäosus kõrgem

- **Koilid (Coils)**

- Migreeruvad veresoone sees
- ei toimi kui ei ole mõõtnetelt veresoone jaoks sobilikud
- **vajalik korralik tihke „kork“ et veresoon okluseeruks**
 - maksa sees hästi arenenud kollateraaside võrgustik
 - samas „nimedega“ kollateraale vähe

- **Cyanoacrylate liim (n-butyl-2-cyanoacrylate)**

- vedelik, mis tahkestub verega kontakti korral

- (Stendid)

- on võimalik säilitada distaalset verevoolu
- tavaliselt kasutatav **pseudoaneurüsmide korral**

5. Embolisatsiooni strateegia...

► Kaks võimalust:

- **Selektiivne**

- Võrreldes põrna või neeruga on selektiivsust raskemini saavutatav
- „raske trauma on raske“
- Palju kollateraale

- **Mitteselektiivne**

► Sõltub

- verejooksu anatoomiast ja mustrist
- veskuse võimekust, **olemasolevatest vahenditest**

6. AE tüsistused. Maksakoe nekroos.

- **Tüsistuste põhjused multifaktoriaalsed**
 - maksasisese kahjustuse tase ja
 - sellest tulenev maksa düsfunktsioon
 - iatrogeensed sekkumised (k.a ravimid)
 - maksa funktsiooni tase enne traumat
 - soki seisund ning sellega kaasnevad vereringe muutused
- Juhtuvad eelkõige:
 - **maksakoe nekroos**
 - sapilekked
 - peri/intra –hepaatilised abstsessid
 - sapipõie infarkt
- **Maksakoe nekroos on kõige sagedamini dokumenteeritud, kõige olulisem tüsistus.**
 - Protseduuri järgne nekroosi risk kuni 16 %. Mõne uuringu põhjal 42-60%.
- AE protseduuriga kaasneb alati mõningane maksakoe nekroos. **On komplikatsioonina arvestatav kui nekrotiseerub suurem ala või on vajalik kirurgiline sekkumine**
- **Diagnoos CT või intraoperatiivselt.**
- Nekroosi risk ja selle suurus tõenäoliselt sõltub
 - AE selektiivsusest
 - embolisatsioonimaterjalidest
 - vigastuse staadiumist
 - hüpotensioonist
 - ravimitest
 - *Damage Control* operatsioonide arvust
 - intraabdominaalsest kompartment sündroomist

A modern, multicenter evaluation of hepatic angioembolization – Complications and readmissions persist

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ABSTRACT

Background: Indications for angioembolization (AE) following liver injury are not clearly defined. This study evaluated the outcomes and complications of hepatic AE. We hypothesize hepatic angioembolization is a useful adjunct to non-operative management of liver injury but with significant morbidity.

Methods: Subjects were identified utilizing trauma registries from centers in a regional trauma network from 2010 to 2017 with an Abbreviated Injury Scale (AIS) coded hepatic injury and an ICD9/10 for hepatic angiography (HA).

Results: 1319 patients with liver injuries were identified, with 30 (2.3%) patients undergoing HA: median ISS was 26, and median liver AIS was 4. Twenty-three subjects required AE. 81% had extravasation on CT from a liver injury. 63% underwent HA as initial intervention. 43% of AE subjects had liver-related complications with 35% 30-day readmission but with zero 30-day mortality.

Conclusions: While there were zero reported deaths, a high rate of morbidity and readmission was found. This may be due to the angioembolization or the liver injury itself.

Primary angioembolization in liver trauma: major hepatic necrosis as a severe complication of a minimally invasive treatment—a narrative review

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Abstract

The liver is the second most commonly solid organ injured in blunt abdominal trauma. Liver injuries are classified according to the American Association for the Surgery of Trauma Injury Scale. The choice of Non-Operative Management is based on generalized clinical patients' conditions combined with the evidence on CT scan imaging. To date, there are no consensus guidelines on appropriate patient selection criteria for those who would benefit from angiography and angioembolization. Major hepatic necrosis is a clinical condition of extended liver damage and is the most common complication after angioembolization. Large amounts of necrotic liver require therapy, but it is unclear if the better technique is debridements supplemented by percutaneous drainage procedures or definitive resection. A systematic review of the literature was performed with a computerized search in a database such as Medline for published papers on the use of angioembolization in trauma patients with hepatic injuries and on the most common complication, the major hepatic necrosis. The systematic review was conducted according to the recommendations of the 2020 updated Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines. A total of 3643 patients were included in the study, suffering liver trauma and 1703 (47%) were treated with Non-Operative Management; angioembolization was performed 10% of cases with a variable rate between 2 and 20%. Patients developed different complications. Hepatic necrosis accounted for 16% ranging from 0 to 42%. 74% of patients underwent operative management with a mortality rate of 11%. High-grade liver injuries pose significant challenges to surgeons who care for trauma patients. Many patients can be successfully managed nonoperatively. In hemodynamically stable patients with arterial blush, without other lesions requiring immediate surgery, selective and super-selective AE of the hepatic artery branches is an effective technique. However, these therapies are not without complications and major hepatic necrosis is the most common complication in high-grade injuries. Level III, Systematic review

Keywords Major hepatic necrosis · Liver trauma · Angioembolization · Non-Operative Management

6. AE tüsistused. Suremus

- ▶ Täpne suremuse risk teadmata
- Keskmine suremus < 10%
 - otseselt AE-ga ei ole tüsistusi raporteeritud
 - surm AE tõttu peab olema konkreetse intraprotseduraalse põhjusega
- Mida suurem trauma, seda kõrgem MT aste, seda suurema tõenäosusega on multisüsteemne organismi kahjustus
 - nendes olukordades raske hinnata AE-ga seotud tüsistusi, mis viivad pt-i surmani

Kokkuvõte seisuga 2022 a.

- ▶ Maksal on **oluline kompleksne roll** inimese organismis.
- ▶ Maksa **verevarustuse keerulisus** mängib samal ajal kaasa ja vastu.
- ▶ Mida ulatuslikum MT, seda rohkem asju tuleb kontrolli all hoida.
- ▶ Mäleta kolm apokalüpsise sõnumitoojat: **koagulopaatia, hüpotermia, atsidoos**
- ▶ Pea meeles, et MT korral mängivad rolli ka **teadmata faktorite koosmõju**.
- ▶ Ainult piltagnostika ei saa dikteerida maksatrauma käsitlemist, **oluline koostöö kirurgidega**
- ▶ IMHO: **Hübriidtubade** olemasolu hõlbustab raviotsusi
- ▶ **AE on ÜKS KOMPONENDIST MT ravi korral**
- ▶ Verejooksuta stabiilset pt-i pigem ei AEi. **AE viib kõrgeenenud morbiidsuseni (vs NOM)** ja ei langeta suremust.
- ▶ AE-ga seotud **tüsistusi** trauma stsenaariumis **raske eristada trauma tagajärjetest**.
- ▶ AE MT korral ei ole võrdne HCC embolisatsiooniga. Morbiidsus peale trauma AEi tõusnud.
- ▶ AE uurimiseks MT korral vajalikud prospektiivsed uuringud!

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2. DOI: 10.1007/s13304-022-01372-9
3. DOI: 10.1016/j.cjtee.2022.04.004
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Täna tähelepanu eest!

