Chinese Journal of Traumatology 25 (2022) 257–263

Contents lists available at ScienceDirect

Chinese Journal of Traumatology

journal homepage: http://www.elsevier.com/locate/CJTEE

Review Article

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

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ARTICLE INFO

Article history:
Received 18 April 2021
Received in revised form
30 January 2022
Accepted 26 February 2022
Available online 13 April 2022

Keywords:
Liver
Trauma
Non-operative management
Angioembolization

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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Peer review under responsibility of Chinese Medical Association.

https://doi.org/10.1016/j.cjtee.2022.04.004

Introduction

Nowadays non-operative management (NOM) is considered as the standard of care for liver trauma in hemodynamically stable patients with an estimated success rate of 80%–90%.[1,2] The safety and success of NOM requires good expertise of surgical, intensive and radiological care.[3] Indications for NOM include: haemodynamic stability, absence of other injuries requiring laparotomy, and set availability of resources and staff.[4,5] In the last 2 decades, endovascular techniques and angioembolisation (AE) have become an important part in the treatment of trauma patients, increasing the success rate of NOM in hepatic injury.[6,7]

In our previous study, we analysed morbidity and mortality in patients who had been treated with primary AE. We found that mild to severe complications may affect the post AE course with wide variability in their incidence between studies.[8] The most recent systematic review available in the literature of NOM evaluated a total of 565 high-grade liver injury patients and confirmed that NOM is associated with a high success rate (92.4%) when compared to operative management.[9]

This article only evaluated the outcomes of NOM. Comparison of outcomes in NOM without radiological intervention for hepatic injury and NOM in patients also treated with AE was considered; however, we assumed that, when indication for AE has been correctly made and the procedure properly performed, those patients should be more likely exposed to complications.

The primary objective of this systematic review was to assess the incidence of complications in patients who sustained liver injuries and were treated with NOM with only clinical observation. Provided the consideration mentioned above, an interpretation of the results with reference to the complications sustained by patients who are treated with NOM and AE was also made.

Methods

Search methods

MEDLINE (via PubMed), Cochrane Central Register of Controlled Trials databases, EMBASE, and Google Scholar, were systematically searched for relevant studies focused on the NOM of liver trauma, both blunt and penetrating, published between January 1990 and June 2020. Terminology search including “liver trauma”, “hepatic trauma”, “conservative management”, “non operative management”, were combined as follows: (hepatic OR liver AND trauma AND conservative management); (hepatic OR liver AND trauma AND non operative management).

Additional studies were identified based on database suggestion as well as through manual searches for reference lists of all relevant articles. The first literature search was performed in April 2020, and it was completed in June 2020. Data were collected based on the preferred reporting items for systematic reviews and meta-analyses (Fig. 1).

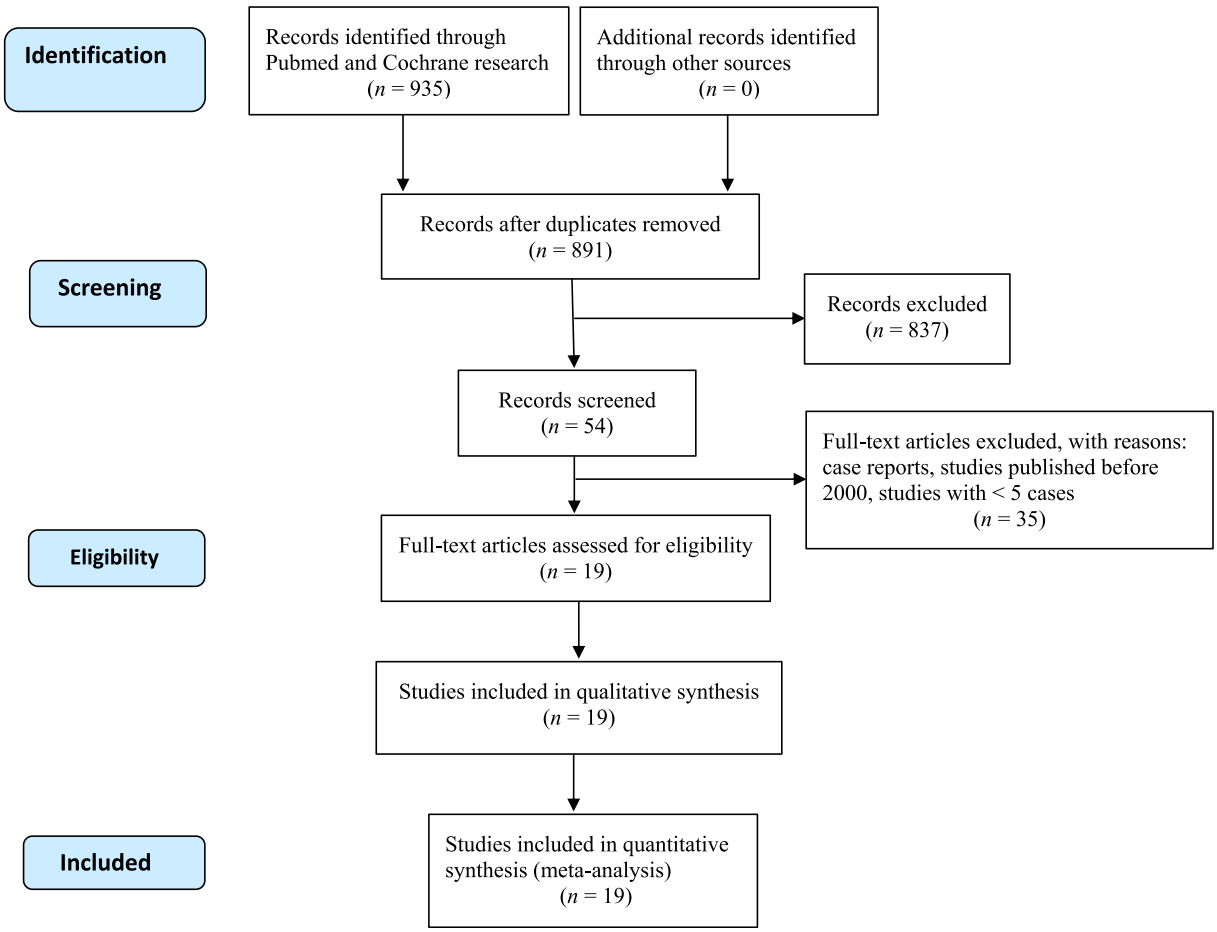

Fig. 1. PRISMA 2009 flow diagram.

Selection of studies

This systematic review included prospective and retrospective cohort studies written in English in which main outcomes of NOM in hepatic trauma have been reported. No restrictions were placed on publication status.

Including criteria for the systematic review were the following: (1) the study enrolled patients with traumatic liver injuries (blunt and penetrating); (2) NOM was used on patients with traumatic hepatic injuries only, both blunt and penetrating (3) at least one outcome of interest was described; (4) morbidity outcomes from NOM have been provided.

Exclusion criteria included: (1) studies reporting the outcome of NOM without separating liver from other solid organs; (2) studies reporting NOM complications together with those post-intervention; (3) case reports; (4) studies including less than 5 cases; (5) studies not written in English; (6) studies including patients who had NOM with AE as primary management. However, data for comparison of outcomes between NOM only and NOM with AE were extrapolated from our previous review.[8]

Types of outcome measures

Primary outcomes assessed were the efficacy of NOM and overall morbidity and mortality. Specific causes of morbidity, such as bile leak, liver abscess and biloma, hepatic ischemia, gallbladder necrosis, compartment syndrome, pseudoaneurysms and fistulas were also investigated. To characterise the severity of the liver injury, the American Association for the Surgery of Trauma (AAST) classification has been used, as it provides guidance for management of hepatic trauma and it has been used in all the studies analysed.[10]

Data extraction

Two reviewers independently evaluated the eligibility of studies and extracted data. Inconsistencies were resolved by mutual discussion. Inclusion and exclusion criteria, country and year of publication, study type, number of patients treated with NOM, and the general characteristics of patients were extracted.

Data synthesis and analysis

Results were tabulated and presented using descriptive statistics and variables have been expressed as absolute numbers, means, percentages, ranges and ratio, when appropriate. Because of the lack of comparative studies, a quantitative meta-analysis was not performed.

A review of the results in reference to the incidence of complications in patients with liver injuries treated with NOM with only clinical observation and patients treated with NOM and AE was carried out, analysing the results of the present study with those from a previous systematic review published by our group but trying to clearly state the due differences between different stage of injuries and indication of treatment.[8] Statistical significance has been calculated using the Chi-square test.

Results

Description of studies

An overall of 891 references was identified through electronic database searches and other sources, and 837 searches were rejected as not matching the inclusion criteria. The residual 54 studies (Fig. 1) were considered potentially appropriated to be included in the systematic review, and underwent full article review. Furtherly, 35 articles were excluded and a total of 19 studies, published between January 1995 and June 2020, were eventually eligible for inclusion in this study.[11–29]

Five of the studies came from the USA, 3 from South Africa, 2 from China (Taiwan), 1 from the UK, Canada, Italy, Netherlands, Switzerland, Greece, India, Kuwait and Spain, respectively. Eight of the studies enrolled were prospective cohort studies and 11 were retrospective cohort studies. The characteristics of the included studies are summarised in Table 1. All patients included in the studies, objects of this systematic review were treated with NOM, following the criteria for conservative management in liver injuries, without any further intervention, either surgical or radiological.

A total of 2656 patients treated non-operatively were included in the patient study population. Excluding 185 patients from one paediatric study; the mean age of patients was 31.9 years (range

Table 1
General characteristics of patients as reported in the studies included in the systematic review.

Studies	Year	Study type	Country	Total (*n*)	Mean age (years)	ISS (median)	Trauma grade, *n* (%)				
							I-II	III	IV	V	≥ III
Brillantino et al.[28]	2018	Prospective	Italy	176	39	16	111 (63.1)	38 (21.6)	19 (10.8)	8 (4.5)	65 (36.9)
Navsaria et al.[29]	2018	Prospective	South Africa	54	27	25	21 (38.9)	NR	NR	NR	33 (61.1)
Hommes et al.[27]	2015	Prospective	South Africa	99	29	22	NR	NR	NR	NR	41 (41.4)
Hsieh et al.[24]	2014	Retrospective	Taiwan, China	80	31	19.7	NR	NR	NR	NR	80 (100.0)
Bertens et al.[26]	2014	Retrospective	Canada	348	38	33	204 (58.6)	82 (23.6)	59 (17.0)	3 (0.9)	144 (41.4)
Yuan et al.[25]	2014	Retrospective	Taiwan, China	288	34	24.2	114 (39.6)	90 (31.3)	79 (27.4)	5 (1.7)	174 (60.4)
Asfar et al.[23]	2014	Prospective	Kuwait	98	29	NR	36 (36.7)	NR	NR	NR	62 (63.3)
van der Wilden et al.[22]	2012	Retrospective	US	262	33	27	NR	NR	NR	NR	262 (100.0)
Bernardo et al.[20]	2010	Retrospective	Spain	87	32	25	39 (44.8)	28 (32.2)	7 (8.0)	0	35 (40.2)
Saltzherr et al.[21]	2010	Retrospective	Netherlands	81	29	22	56 (69.1)	NR	NR	NR	25 (30.9)
Navsaria et al.[18]	2009	Prospective	South Africa	63	27	19.6	26 (41.1)	16 (25.4)	15 (23.8)	6 (9.5)	37 (58.7)
Schnuriger et al.[19]	2008	Retrospective	Switzerland	63	37	31	NR	NR	NR	NR	63 (100.0)
Gourgiotis et al.[16]	2007	Retrospective	Greece	43	32	NR	35 (81.4)	2 (4.7)	NR	NR	2 (4.7)
Srinivasan et al.[17]	2007	Retrospective	India	79	30	NR	NR	66 (83.5)	10 (12.7)	3 (3.8)	79 (100.0)
Coughlin et al.[14]	2004	Retrospective	UK	48	25	NR	NR	NR	NR	NR	NR
Giss et al.[15]	2004	Retrospective	US	185	Pediatric study	>15	127 (68.6)	47 (25.4)	4 (2.2)	0	51 (27.6)
Velmahos et al.[13]	2003	Prospective	US	55	35	19	NR	NR	NR	NR	34 (61.8)
Malhotra et al.[12]	1999	Prospective	US	560	34	20.7	NR	NR	NR	NR	NR
Croce et al.[11]	1995	Prospective	US	112	33	34	30 (26.8)	NR	NR	NR	70 (62.5)

ISS: injury severity score; NOM: non-operative management; NR: not reported.

27–39 years). The grade of liver injury according to AAST has been reported including all grades from I to V. Nine out of 19 articles reported the exact number of patients divided per grade of injury; 8 studies reported only on patients with AAST grade ≥ III and 2 studies did not comment on the grade of liver injury.

Mechanism of injury

Bernardo et al.[20] and Saltzherr et al.[21] included in their study both penetrating and blunt liver trauma; however, they included the outcomes in the same analysis with no distinctions. Both the papers from Navsaria et al.[18,29] analysed only patients who sustained gunshot wounds. All the other authors analysed patients with blunt hepatic injuries.

Efficacy

All outcome measures have been evaluated to assess the feasibility and the complications associated with NOM when no further intervention (i.e., AE) was required. For all the outcomes, the detailed results are reported in Tables 2&3. The NOM success rate ranged 85%–99% in a total of 2506 patients. Three studies did not report on NOM failure[19,21,25] and they have been considered as successful NOM.

Morbidity

All 19 studies reported complications, with an incidence of 6.9% (174 patients), and a range between 0% and 33% (Table 2). One study did not comment on the type of complications.[24] The morbidity details are showed in Table 3. The most commonly reported complication was hepatic collection (abscess/biloma), reported in 12 studies, with an incidence rate of 2.8% (69 patients), and a range 2%–20%. Thirty-nine cases of bile leak (1.5%) were reported in 8 studies, with a range 1%–13%. Hepatic haematoma was identified in 6 studies, with an incidence of 0.5% (14 patients), and a range 1%–6%.

Bleeding has been reported in 4 studies for a total of 15 patients (0.6%) with incidence ranging 3%–7%. The occurrence of fistula, reported in 5 studies (2 bilio-cutaneus, 2 arterio-venous, 2 bilio-pleuro), had an incidence of 0.35% (9 patients), and a range between 0.5% and 4%. Pseudoaneurysm of the hepatic artery was reported in 3 studies, with an incidence of 0.4% (11 patients), and a range between 1% and 4%. Compartment syndrome was reported in 3 studies, with an incidence of 0.2% (6 patients), and a range between 1% and 4%. The incidence of peritonitis, reported in 1 study, was 0.1% (2 patients). Other complications with incidence less the 0.3% included deep venous thrombosis and pulmonary embolism reported in 2 patients from 1 study, respiratory complications in 4 patients from 2 studies, 2 patients with liver failure, 5 patients with wound infection, 1 patient with gallbladder necrosis and 3 patients with non-specified abdominal complications.

Table 2
Primary outcomes of the selected studies.

Studies	Year	NOM, *n* (%)		Morbidity *n* (%)
		Successful	Failed	
Brillantino et al.[28]	2018	170 (96.5)	6 (3.5)	12 (7.2)
Navsaria et al.[29]	2018	51 (94.5)	3 (5.5)	5 (10.1)
Hommes et al.[27]	2015	94 (95.1)	5 (5.0)	7 (7.1)
Hsieh et al.[24]	2014	77 (96.3)	3 (4.1)	5 (6.2)
Bertens et al.[26]	2014	288 (99.0)	3 (1.0)	9 (3.2)
Yuan et al.[25]	2014	220 (100.0)	NR	4 (2.1)
Asfar et al.[23]	2014	94 (96.1)	4 (4.2)	13 (14.2)
van der Wilden et al.[22]	2012	239 (91.2)	23 (9.1)	30 (12.5)
Bernardo et al.[20]	2010	74 (85.3)	13 (15.2)	5 (7.1)
Saltzherr et al.[21]	2010	81 (100)	NR	10 (12.2)
Navsaria et al.[18]	2009	58 (92.2)	5 (8.1)	3 (5.1)
Schnuriger et al.[19]	2008	63 (100.0)	NR	7 (11.0)
Gourgiotis et al.[16]	2007	37 (86.1)	6 (14.2)	5 (13.5)
Srinivasan et al.[17]	2007	70 (89.2)	9 (11.3)	23 (33.3)
Coughlin et al.[14]	2004	43 (90.3)	5 (10.1)	5 (12.2)
Giss et al.[15]	2004	182 (98.1)	3 (2.1)	7 (4.1)
Velmahos et al.[13]	2003	47 (85.5)	8 (14.5)	1 (2.2)
Malhotra et al.[12]	1999	518 (92.5)	42 (7.5)	0
Croce et al.[11]	1995	100 (89.2)	12 (11.2)	23 (23.3)

NOM: non-operative management; NR: not reported.

Mortality

Mortality was reported in 9 studies ranging between 1% and 13% (Table 4). Among studies that specified the causes of death, brain injuries and pulmonary complications were the most common[11,13,20,24] with only 1 study reporting liver-related mortality.[15] Moreover, only 2 studies specified if the mortality in NOM patients occurred within the successful group[11,13]; the other studies reported all death from NOM including both successful and failed cases.

Discussion

It is well established how the management of hepatic trauma has moved to a conservative approach, and how surgical intervention is now limited to haemodinamic unstable cases.[13,22,30,31] In this review, we specifically focused on the success rate and complications of NOM without the use of interventional radiology. Our results show homogeneity in the types of complications described, with several studies reporting higher incidences of few particular complications (i.e., collection and bile leak).

A main limitation of this study derives from the fact that 4 out of 17 studies have considered only patients with higher AAST grade (III and above) and did not report complications of NOM for lower injury grade. Moreover, the majority of the studies did not divide morbidities by AAST grade and the grade of hepatic injury has not been reported in several studies.

It is well stated in literature how complications are primarily related to the grade of liver injury and reported complication rates in NOM range from 0% to 7% when all grades are considered, and can be as high as 14% when only high-grade injuries are considered.[32] The incidence of complications reported by the studies included in this review varies from 0% to 33%, showing a variability that may be result from multiple factors, which are difficult to identify and analyse. Bile leak and liver collection (either biloma or abscess) were the most commonly observed complications.

The mortality rate is difficult to interpret since most of the studies, apart from 2, did not specify whether the deaths occurred among the successful cases or the failed ones. Complications such as compartment syndrome, peritonitis and fistula were rare. Pseudoaneurysms is also a very low incidence in all studies. This complication is normally found out on follow-up scans, unless patient develops bleeding from the pseudoaneurysm. However, to date, there is a lack of consensus on routine use of CT scan as short- and long-term follow-up in patients with liver injury, especially those treated with NOM. Some authors recommend a “selective surveillance” with follow-up CT when clinically indicated, but the selection criteria continue to be unclear.[32–34]

Our data showed low incidence of pseudoaneurysm, raising the question whether routine follow-up in patients treated with NOM should be performed. The low incidence in pseudoaneurysm and fistula formation showed in our study may reinforce the results showed by Mebert et al.[35] in their study, where 920 CT scans were

Table 3
Secondary outcomes (specific causes of morbidity) of the selected studies.

Studies	Year	Successful NOM (*n*)	Bile leak, *n* (%)	Hepatic pseudo-aneurism, *n* (%)	Fistula, *n* (%)	Hepatic Abscess/ Biloma, *n* (%)	Hepatic haematoma, *n* (%)	Bleeding, *n* (%)	Abdominal compartment syndrome, *n* (%)	Peritonitis, *n* (%)	Others, *n* (%)
Brillantino et al.[28]	2018	170	NR	7 (4.2)	4 (2.2)	NR	1 (1.2)	NR	NR		
Navsaria et al.[29]	2018	51	NR	NR	2 (4.3)	2 (4.2)	NR	NR	NR		1 (2)
Hommes et al.[27]	2015	94	NR	NR	NR	3 (3.3)	1 (1.2)	NR	1 (1.2)	2 (2.0)	
Hsieh et al.[24]	2014	77	NR	NR	NR	NR	NR	NR	NR		
Bertens et al.[26]	2014	288	NR	3 (1.3)	NR	5 (2.1)	NR	NR	NR		2 (1)
Yuan et al.[25]	2014	220	4 (2.2)	NR	NR	NR	NR	NR	NR		
Asfar et al.[23]	2014	94	1 (1.3)	NR	NR	1 (1.0)	NR	7 (7.2)	4 (4.1)		
van der Wilden et al.[22]	2012	239	16 (7.1)	NR	NR	14 (6.1)	NR	NR	NR		
Bernardo et al.[20]	2010	74	1 (1.2)	NR	NR	NR	NR	1 (1.3)	NR		3 (4)
Saltzherr et al.[21]	2010	81	1 (1.3)	NR	NR	2 (2.0)	NR	5 (6.1)	NR		2 (2)
Navsaria et al.[18]	2009	58	NR	NR	1 (2.1)	2 (3.1)	NR	NR	NR		
Schnuriger et al.[19]	2008	63	NR	NR	NR	6 (9.5)	4 (6.0)	NR	1 (1.5)		
Gourgiotis et al.[16]	2007	37	2 (5.4)	NR	NR	3 (8.4)	NR	NR	NR		
Srinivasan et al.[17]	2007	70	9 (13.3)	NR	1 (1.3)	6 (8.5)	NR	2 (3.2)	NR		5 (7)
Coughlin et al.[14]	2004	43	5 (12.1)	NR	NR	NR	NR	NR	NR		
Giss et al.[15]	2004	182	NR	NR	1 (0.5)	5 (3.3)	NR	NR	NR		1 (0.5)
Velmahos et al.[13]	2003	47	NR	1 (2.2)	NR	NR	NR	NR	NR		
Malhotra et al.[12]	1999	518	NR	NR	NR	NR	NR	NR	NR		
Croce et al.[11]	1995	100	NR	NR	NR	20 (20.0)	NR	NR	NR		3 (3)

NOM: non-operative management; NR: not reported.

Table 4
Mortality reported in the studies.

Authors	Year	Mortality, *n* (%)	Cause of death
Hommes et al.[27]	2015	1 (1.2)	NR
Hsieh et al.[24]	2014	4 (5.3)	3 Intracranial hemorrhage 1 Pulmonary complications
van der Wilden et al.[22]	2012	15 (6.1)	NR
Bernardo et al.[20]	2010	2 (2.2)	1 ARDS 1 Hospital acquired pneumonia
Schnuriger et al.[19]	2008	2 (3.1)	NR
Srinivasan et al.[17]	2007	3 (4.3)	3 Brain injury
Giss et al.[15]	2004	2 (1.1)	2 Liver related
Velmahos et al.[13]	2003	6 (13.2)	Related to associate injuries including head, pelvis, thorax and their complications
Croce et al.[11]	1995	8 (8.3)	2 Brain injury 1 Pulmonary complication 5 MOF

NR: not reported; ARDS: acute respiratory distress syndrome; MOF: multiple organ failure.

performed to detect complications, but only 1 patient required intervention as a result of the CT scan findings.

In our previous study, we focused on the outcomes related to primary AE in NOM, and we found that complications ranging from mild to severe can affect the post AE course, with wide variability in their incidence reported between studies. We highlighted the need for further studies to clarify in more detail how and whether these complications were related to the procedure itself and not simply a consequence attributable to the trauma.[8]

Provided the consideration we made in the introduction, when analysing the results of the present study with an eye to the results from our previous review,[8] bile leak and collection were the most common complications reported in NOM and NOM with AE. The incidence in NOM only has been reported to be 1.5% and 3%, respectively, but being higher in NOM with AE (6.1% and 8.4%, respectively), showing a statistically significant result ($p = 0.00001$). This was expected considering also that our previous systematic review on primary AE studied only patients with grade III and above liver injuries. When focusing only on patients with grade III and above in both cases, the incidence of bile leak rises to 5% and the 1 of collection to 5.3% in NOM only, with no statistically significant results between the 2 types of management ($p = 0.45$ and $p = 0.06$, respectively). It could assume that bile leak and collection could be linked more to the severity of the liver injury than the treatment used, but more data are needed to confirm this finding.[36]

Table 5
Confrontation between common complications in NOM and NOM with AE, (%).

Complications	Successful NOM ($n = 2506$)	Primary AE ($n = 570$)	Successful NOM grade ≥ III ($n = 511$)
Bile leak	1.5	6.1	5.0
Biloma/abscess	3.0	8.4	5.3
Gallbladder necrosis	0.1	3.9	0.1
Compartment syndrome	0.2	2.5	1.1
Peritonitis	0.1	1.9	0.1

NOM: non-operative management; AE: angioembolization.

The other complications reported in both groups were compartment syndrome (2.5% in NOM with AE *vs.* 0.2% in NOM only), peritonitis (1.9% in NOM with AE *vs.* 0.1% in NOM only) and gallbladder ischemia (1.9% in NOM with AE *vs.* 0.1% in NOM only). There is a statistically significant difference between the 2 treatment groups when considering only patients with severe grade injuries for gallbladder necrosis ($p = 0.04$) and peritonitis ($p = 0.00007$). The compartment syndrome did not show statistically significant difference when considering patients with higher grades ($p = 0.11$). From the studies reporting compartment syndrome among the morbidities, only Asfar et al.[23] specified that the complication occurred only in patients with grade V liver injury. It seems therefore that some of these complications are more linked to AE itself.[37] Whilst it could appear more obvious how gallbladder ischemia could be related to AE,[38] it is less obvious for peritonitis. Regarding the compartment syndrome, it appears to be likely more associated to the most severe livery injuries that are often associated with politrauma. The comparison between the complications found both in primary AE in our previous study[8] and NOM without AE are shown in Table 5.

In conclusion, NOM with simple clinical observation showed an overall low incidence of complications, but higher for bile leak and collections. When comparing these results in NOM with AE, there is a statistically significant difference in the incidence of morbidities. Only in patients with grade III and above injuries the incidence of bile leak, collections and compartment syndrome does not show a statistically significant difference with the equivalent found in the AE group; however, the latter result is limited by the small number of studies available and it requires further investigations.

All the other complications are significantly less frequent among the NOM with clinical observation group despite the grade of injury when compared to the AE group. Moreover, considering the low incidence of complications, the routine CT follow up does not seem to be necessary especially in low grade injuries and it should be considered if clinically indicated.

As our main endpoint was to enlighten complications from liver injury underwent to simply observation, despite listing morbidity in Table 2, Table 3 demonstrates that over half of the studies did not report the incidence of bile leak, hepatic pseudoaneurysm, fistula, hepatic hematoma, bleeding, compartment syndrome or peritonitis. Thus, the morbidity was relatively low and only reported in 9 of the 19 studies.

The choice of treatment with AE in liver trauma is not guided by the risk of complications; however, the results shown by this study reported a difference in morbidity between simple clinical observation and AE and this fact can be taken into account in cases where the indications for interventional radiology is not straightforward. In a retrospective study by Yuan et al.[39], attempts of AE were negative in 26.4% (48/182) of patients who were taken to the angiography suite following a contrast blush on the initial CT scan.

As already suggested in the literature,[23] it seems reasonable to consider a watchful policy and selective use of AE to minimise the associated complications that can occur.

Funding

Nil.

Ethical statement

Not applicable.

Declaration of competing interest

Authors have no conflict of interest or financial ties to disclose.

Author contributions

All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by Francesco Virdis and Mauro Podda. The first draft of the manuscript was written by Francesco Virdis. Mauro Podda, Salomone Di Saverio, Jayant Kumar, Roberto Bini, Carlos Pilasi and Isabella Reccia reviewed and commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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