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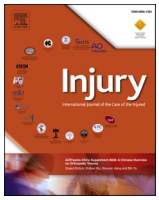

Review

The influence of pre-injury anticoagulant or antiplatelet agents on outcomes in trauma patients sustaining abdominal solid organ injuries: A scoping review

Gi Young Seo [a,b], Arpita Das [c,d], Silvia Manzanero [c,d,e], Keeyeon Kim [b], Carl Lisec [a,b,c,f], Michael Muller [a,b,c,f,*]

[a] Faculty of Medicine, University of Queensland, Brisbane, Queensland, Australia
[b] Department of General Surgery, Royal Brisbane and Women's Hospital, Brisbane, Queensland, Australia
[c] Jamieson Trauma Institute, Royal Brisbane and Women's Hospital, Brisbane, Queensland, Australia
[d] School of Clinical Sciences, Queensland University of Technology, Brisbane, Queensland, Australia
[e] Australian Institute of Bioengineering and Nanotechnology, University of Queensland, Brisbane, Queensland, Australia
[f] Trauma Service, Royal Brisbane and Women's Hospital, Brisbane, Queensland, Australia

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ABSTRACT

Background: Indications for, and usage of, anticoagulant (AC) and antiplatelet (AP) agents is increasing. In this context, it is important to understand the evidence base of the effect of pre-injury AC/AP agents on patient outcomes in the context of traumatic solid organ injury (SOI) to inform management protocols.
Methods: A scoping review of the literature was undertaken with a systematic search strategy within the PubMed and Scopus databases. Study characteristics, clinical outcomes and outcome measures including mortality, hospital length of stay, admission to intensive care units, length of stay in intensive care and management details were extracted from included studies.
Results: The search identified six eligible studies reporting results from a total of 26,960 patients. Patients on AC/AP are more likely to fail non-operative management (NOM) than their non-AC/AP counterparts; at the same time, they are less likely to be operated on as a first line of management. Clinical outcome measures (mortality, length of stay, admission to intensive care units, and length of intensive care unit stay) were heterogeneous across studies, but it is likely that AC/AP patients have poorer outcomes in SOI. Results on transfusion requirements were inconclusive.
Conclusion: Few studies have examined the effect of pre-injury anticoagulation on outcomes in trauma patients sustaining solid organ injuries. Future studies should more closely examine solid organ trauma within the elderly group, as well as the effect of newer AC/AP agents in current use.

Introduction

The use of anticoagulant and antiplatelet (AC/AP) therapy is increasing as an essential adjunct for the management of many chronic health conditions [1]. Modern AC/AP therapies are varied and complex; this is particularly true for novel oral anticoagulants (NOACs). Such agents have steadily risen in popularity in recent decades [1]; few NOAC reversal agents are readily available and approved for use, and monitoring methods are more complex than those of older agents [2,3].

Consequently, an increasing number of trauma presentations will be complicated by pre-injury AC/AP therapy. In the context of general traumatic injuries, many studies have clearly demonstrated that pre-injury AC/AP therapy is largely associated with greater rates of mortality, length of stay, and poorer outcomes [4–6]. In the context of intracranial haemorrhage, prior anticoagulation has been shown to be associated with early neurological deterioration, poorer functional outcome and mortality, though the effects are variable between anticoagulant agents [7–9]. Pre-injury AC/AP should be a significant consideration in the acute management of trauma patients.

Spleen, liver, and other solid organ injuries (SOI) commonly occur as a consequence of abdominal trauma, and can have serious implications for haemorrhage, haemodynamic stability, morbidity, and mortality

* Correspondence author at: Butterfield St, Herston Qld 4006, Australia.
E-mail address: michael.muller@health.qld.gov.au (M. Muller).

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[10]. Pre-injury AC/AP therapy is also known to increase the incidence of SOI from blunt trauma [11,12]. Accordingly, the use of pre-injury anticoagulant treatment is an important factor to consider in the management of patients with SOI.

Understanding the role of comorbidities in trauma in the context of an aging population is vital. A statewide study of geriatric-specific trauma protocols across trauma centres in Pennsylvania, United States [13] showed age-specific protocols specific to solid organ injury led to significantly better-than-expected mortality ratios. Because a key factor that makes this elderly group vulnerable in trauma is polypharmacy and pre-injury anticoagulant/antiplatelet medication [14], it is vital to explore this area to consolidate an evidence base that can strengthen protocols for frail trauma patients.

Despite this, our understanding of the effect exerted by pre-injury anticoagulation on patient outcomes specifically in solid organ trauma is preliminary. Thus, this review aims to compile the current evidence on the risk to patient outcomes posed by pre-injury anticoagulant or antiplatelet agents in the setting of traumatic solid organ injury.

Methods

This scoping review is guided by the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) [15]. The protocol is registered at the Open Science Framework [16].

Research question

This review aims to compare patients sustaining an abdominal solid organ injury from a traumatic mechanism who are, and are not, influenced by pre-injury anticoagulant/antiplatelet agents. Results of interest were the differences in clinical outcomes and management strategies employed; the details of this are discussed in the "data extraction" section.

Eligibility criteria

The inclusion criteria were as follows, with eligible studies meeting all categories: 1) patients sustaining solid organ injuries including spleen, kidney, and liver; 2) pre-injury anticoagulant or antiplatelet medication use; 3) injuries sustained through any traumatic mechanism; 4) full-text peer-reviewed articles published by a journal as a preprint or in final form; 5) all original research including randomized controlled trials, non-randomized controlled trials, cohort studies, case-control studies, and cross-sectional studies,

The exclusion criteria were as follows: 1) review articles; 2) studies published in a language other than English; 3) studies for which the full text is not available; and 4) abstracts or full-text articles published as a short communication such as letters to the editor, guidelines, websites, magazines.

Search strategy

Relevant studies were identified through an electronic search of PubMed and Scopus. Search terms used in each database are included in Appendix 1.

Data extraction

Results of each of the searches were exported from the relevant databases and compiled into Covidence (Veritas Health Innovation, Melbourne, Australia), then duplicates removed. All records from the search were also imported into EndNote (Version 20.1; Clarivate, Pennsylvania, USA) and duplicates were removed. Two independent reviewers (GS, KK) conducted an initial screen of titles and abstracts of all identified citations to select articles for full-text review, at which stage the selected articles underwent full-text review against the eligibility criteria by the two reviewers (GS, KK). Any conflicts in opinion among the two reviewers were discussed with the option of referring to a third reviewer; no disagreements required a third reviewer.

Data were extracted, broadly, in three categories: 1) study characteristics (authors, title, year, study design, sample size, country where the study was conducted, patient demographics such as age and sex); 2) clinical outcomes and outcome measures (mortality, hospital length of stay, admission to intensive care units, length of stay in intensive care); and 3) management (transfusion requirements, interventions). Data were collated into a shared Microsoft Excel template available to both reviewers. GS performed the initial extraction; KK performed a second extraction and results were compared for accuracy. The template included headings for each category of data extracted.

Synthesis of results

Extracted data were synthesised into tables. Descriptive statistics were recorded. Where possible, means (and standard deviations) or medians (and interquartile ranges) were used. *p*-values were extracted from the original studies and represented according to a unified schema in this paper with the level of significance set as $p < 0.05$. Where matched analyses were available, the data from the matched analysis were tabulated.

Results

Study selection

The literature search identified a total of 1832 results, from which 95 duplicates were removed. The initial title and abstract review excluded 1712 results, leaving 25 results for full-text review. Following full-text review, 19 studies were excluded. As a result, a total of six studies [17–22] were included for the current scoping review. The PRISMA diagram representing this process is shown in Fig. 1.

Study characteristics

Table 1 outlines the characteristics of the included studies. This scoping review included six retrospective studies [17–22], and of them, three used a propensity-matching technique to adjust for potential confounders [20–22]. Of the matched studies, Reina et al. [22] controlled for patient demographics, initial vital signs and GCS, injury severity score (ISS), comorbidities, in-hospital venous thromboembolism prophylaxis. The two studies by Huang and colleagues [20,21] controlled for patient demographics, year of injury, comorbidities, and associated injuries. The six included studies included a total of 26,960 patients. Four of the six were conducted in the United States [17–19,22], and the remainder in Taiwan [20,21]

Four studies [17–19,22] included a variety of AC/AP agents; another study examined aspirin only [20]; and another study examined warfarin only [21]. Regarding injury type, four studies [19–22] included blunt only, and two [17,18] included a mix of blunt and penetrating. With regard to the targeted organs of interest; two studies included spleen only [18,19], two included liver and spleen [17,20], and two included liver, spleen, and kidney [21,22]. In all of the non-matched studies [17–19], the non-AC group was significantly younger than the AC group (Table 1), with the age differential between the groups ranging from 14.6 [19] to 26.6 [18]. With respect to severity of trauma, in one study [18], the non-AC/AP group had more severe trauma compared to their AC/AP counterparts as recorded by the mean injury severity score (ISS) (22.5 ± 13.1 vs. 18.2 ± 10.6, $p < 0.001$). The remaining studies indicated no difference. In all of the propensity-matched studies except for the spleen arm of [20], the non-AC/AP group had sustained significantly more severe trauma, but the propensity matching process eliminated this bias [20–22].

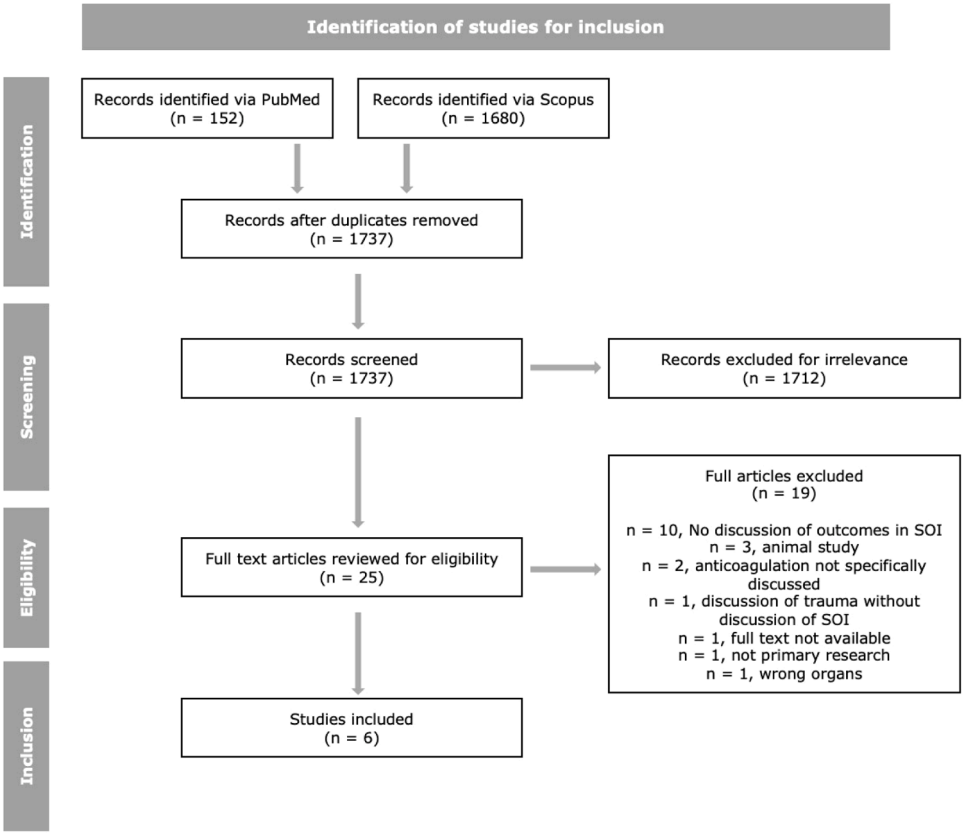

Fig. 1. PRISMA diagram representing the process of study selection.

Table 1
Characteristics of included studies.

Study					Patient					Injury		
						Sex (% Male)		Age (mean, SD)				
Author, Year		Country	Design	Total sample size	Patient inclusion criteria	AC/AP	Non-AC/AP	AC/AP	Non-AC/AP	AC/AP agent	Types of injury	Organ affected
Bhattacharya et al., 2021	[18]	United States	Retrospective	18,749	Adults sustaining splenic injury from any mechanism	64.1	67.2	68.4 (14.8)	41.8 (17.8)	Not stated	Mixed (Blunt, 98 %)	Spleen only
Bhattacharya et al., 2020	[17]	United States	Retrospective, multicentre	1254	Adults sustaining liver and/or spleen injuries from any mechanism	70	68	60.9 (19.6)	38.6 (18.3)	Warfarin (70 %) NOAC (27 %) Heparin (6 %)	Mixed	Liver and spleen (Liver, 47 %)
Dougherty et al., 2019	[19]	United States	Retrospective	168	Adults aged 50–79 sustaining spleen injury	60	67	76	61.4	Not stated	Blunt	Spleen only
Reina et al., 2022	[22]	United States	Retrospective, matched cohort	2709 (post-match)	Adults sustaining isolated blunt abdominal solid organ injury who underwent non-operative management	63	62.8	71 [13]	70.7 (13.4)	Not stated	Blunt	Liver, spleen, kidney
Huang et al., 2021	[20]	Taiwan	Retrospective, matched cohort	3621 (post-match)	Patients sustaining blunt liver and/or spleen injuries on aspirin, and their non-aspirin matched counterparts	64.1	62.1	58.1 (17.1)	58.2 (17.3)	Aspirin only	Blunt	Liver and spleen (Liver, 57 %)
Huang et al., 2022	[21]	Taiwan	Retrospective, matched cohort	459 (post-match)	Patients sustaining blunt hepatic, splenic, or renal injuries	66.7	71.6	47.8 (19.8)	48.5 (21.9)	Warfarin only	Blunt	Liver, spleen, kidney

AC/AP, anticoagulant or antiplatelet agent. *NOAC,* Novel oral anticoagulant.

Clinical outcomes

Clinical outcome measures in trauma patients sustaining solid organ injuries were extracted from all six studies. Data on mortality, length of stay, admission to the intensive care unit (ICU), and ICU length of stay were collected, as represented in Table 2. Five studies reported on mortality [17,18,20–22], with Dougherty and colleagues [19] omitting this measure. Of these, two studies [18,22] encompassing a total of 21,258 patients indicated a significantly greater mortality in AC/AP patients, with an increase of 6.3 % reported by Bhattacharya et al. [18] and an increase of 2.5 % reported by Reina et al. [22]. Three other studies [17,20,21] indicated no significant difference in mortality between the two groups. Effect sizes of mortality statistics are represented in Fig. 2A. All included studies reported on length of hospital stay [17–22]. Hospital stays were significantly longer in two studies encompassing 21,458 patients [18,22], and no significant effect was reported in the remaining four studies [17,19–21]. ICU admission was documented in two studies [17,18]. Bhattacharya et al. reported that non-AC/AP patients were more likely to be admitted to ICU (31.8 % vs 23.5 %, $p < 0.005$) [18], while a 2020 study by the same author (separate cohort) indicated no significant difference [17]. Three studies [20–22] reported on ICU lengths of stay. Two studies [18,19] and patients with spleen injury, but not liver injury, and in another [17] showed longer ICU LOS in the AC/AP group. No difference was found for the patients with liver injury in [17].

Management

Data on transfusion requirements, interventional management options, and failure of non-operative management was extracted from six studies [17–22].

Regarding transfusion requirements, data on the proportion of patients receiving any transfusion, as well as the number of units of packed red blood cells (pRBC) and fresh frozen plasma (FFP), were collected (Table 3). Two studies reported on the need for any pRBC transfusion [17,18]. Of these, one study [17] reported that a significantly higher proportion of patients in the AC/AP group required a blood transfusion, while the other [18] showed no significant difference. With respect to the quantitative measurements of transfusion requirements, the AC/AP group required significantly more units of pRBC in one study [21]. However, two studies [17,18] reported the opposite effect, with more units transfused in the non-AC/AP group. All other studies showed no significant difference. FFP units infused were significantly higher in the non-AC/AP group in one study [21] but the opposite effect was seen in another [18], while the remaining studies indicated no significant difference. The use of prothrombin complex concentrate (PCC) was only captured by one study [22], where the AC/AP group received significantly more units of PCC than non-AC/AP (3 % vs 0.2 %, $p < 0.001$).

Data extracted on interventional management is presented in Table 4. Rates of operative management were not significantly different between the AC/AP and non-AC/AP groups across four of the five studies reporting this measure [18–21]. The remaining study [17] indicated that the non-AC/AP group were more likely to undergo operative management. Rates of initial non-operative management (including embolization) were significantly higher in the AC/AP group in three studies [17,18,21] but non-significant in another [20]. Effect sizes of rates of non-operative management across the studies are represented in Fig. 2B. Rates of failure of initial non-operative management were significantly higher in the AC/AP group in two of the three studies reporting this measure [19,22]. The remaining study [17] indicated no effect. The effect sizes of this are represented in Fig. 2C.

Discussion

As the global population becomes older, consideration of the impact of comorbidities and their treatment in the setting of traumatic injury will be a burgeoning field of study. This scoping review has highlighted several aspects of solid organ trauma management in patients who receive anticoagulant or antiplatelet (AC/AP) therapy that deserve attention.

Prior AC/AP therapy leads to increased rates of failure of non-operative management, which includes supportive therapy, medical management, and embolization [19,22]. Effect sizes ranged from two- to twenty-eight-fold increase in failure rates in AC/AP patients when compared to non-AC/AP patients (Table 4). Further, AC/AP patients were more likely to undergo non-operative management as an initial mode of management than their non-AC/AP counterparts [17–19,21], even in propensity-matched studies that controlled for confounders such as age and comorbidity. This is consistent with findings from a study in patients with thoracoabdominal trauma [23], which suggested that the time between admission and surgery was longer for patients on AC/AP. Given the findings in this study, this delay may be attributable to initial attempts at non-operative management or medical optimisation prior to operation.

Lengths of stay (LOS) in the intensive care unit (ICU) were notably longer in the AC/AP group, with a majority of studies indicating this effect [20–22]. There is also some support for increased mortality [18,22] and hospital length of stay [18,22] in the AC/AP group (Table 2). No conclusion can be drawn regarding the transfusion of blood products such as packed red blood cells (pRBC) and fresh frozen plasma (FFP) due to the heterogeneity of effects seen in this review.

NOACs remain a conundrum for optimising the management of trauma patients. Of the included studies, two focused on one agent of interest (aspirin and warfarin respectively) [20,21], one included an assortment of agents with warfarin in the majority [17], and the remaining studies failed to report on included agents [17,19,22]. This allows limited insight into NOACs in solid organ trauma. There are a multitude of reasons for more closely investigating these agents. Firstly, the use of NOACs is overtaking warfarin and other historic drugs as the predominant anticoagulant agents as the predominant anticoagulant

Table 2
Clinical outcomes in trauma patients sustaining solid organ injuries.

		Mortality			Length of stay			ICU length of stay		
		AC/AP			AC/AP			AC/AP		
Author, year		Yes	No	*p*	Yes	No	*p*	Yes	No	*p*
Bhattacharya et al., 2021	[18]	13.3 %	7 %	***	6.3 (3.6–11.1)	5.6 (2.7–11.4)	***	-	–	–
Bhattacharya et al., 2020	[17]	4.7 %	8.2 %	ns	12 (11.6)	6 [3–11]	ns	–	–	–
Dougherty et al., 2019	[19]	–	–	–	8.8	8.4	ns	–	–	–
Reina et al., 2022	[22]	7.6 %	5.1 %	**	17 [12–26]	17 [10–24]	*	11 [7–18]	11 [6–17]	**
Huang et al., 2021 (Liver arm)	[20]	9 %	7.5 %	ns	26.1 (36.4)	26 (77.1)	ns	6.5 (10.9)	6.1 (12.9)	ns
Huang et al., 2021 (Spleen arm)	[20]	8.6 %	7.8 %	ns	29.3 (46.8)	26.6 (46.9)	ns	8.5 (13.2)	7.1 (11.7)	*
Huang et al., 2022	[21]	3.9 %	7.8 %	ns	36.2 (51.0)	29.1 (73.9)	ns	10.7 (16.3)	6.6 (13.1)	***

-, not collected. *AC/AP,* anticoagulant or antiplatelet agent. *ICU,* intensive care unit.
Statistical analyses in this table reflect analyses done by the original authors.
ns, $p > 0.05$; *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.005$.

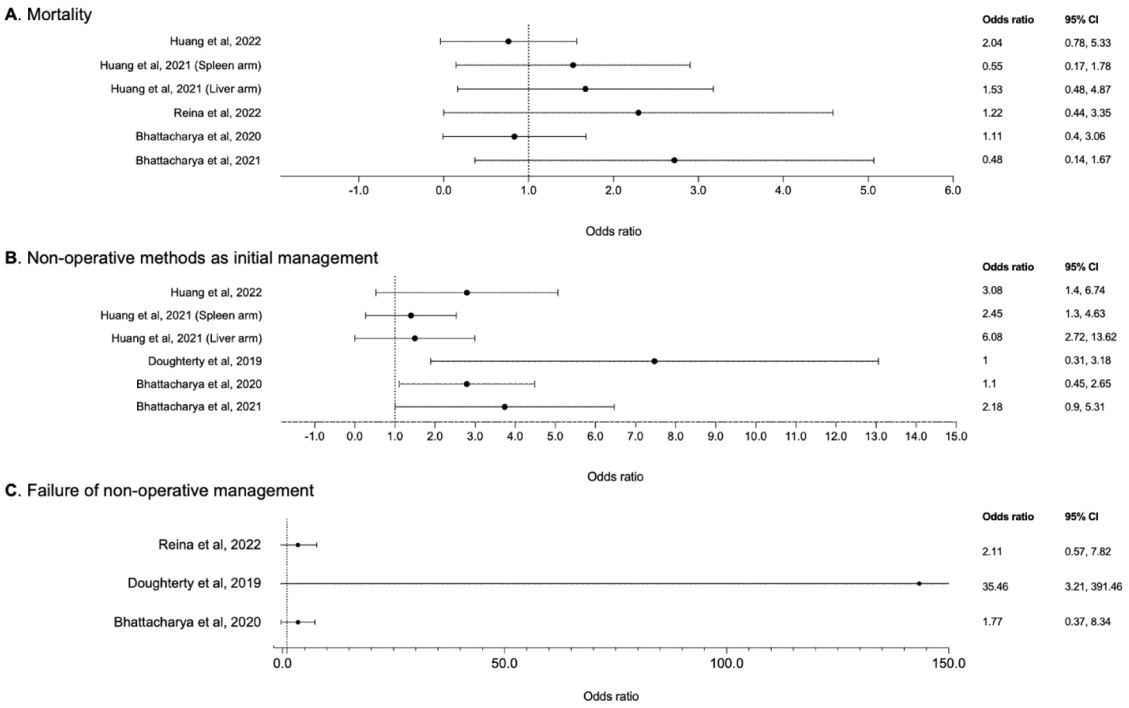

Fig. 2. Forest plots indicating odds ratios and 95 % confidence intervals (95 % CI) for **A)** mortality, **B)** the utilisation of non-operative methods as initial management, and **C)** failure of non-operative management in patients sustaining abdominal solid organ injury on pre-injury anticoagulant/antiplatelet agents compared to their counterparts not on anticoagulant/antiplatelets. Each horizontal line demonstrates the 95 % interval for the effect size. Dashed line indicates null effect (odds ratio = 1), and plots occurring to the right of this line indicates the variable is more likely to occur in patients on pre-injury anticoagulant/antiplatelet therapy (odds ratio > 1).

Table 3
Transfusion requirements in trauma patients sustaining solid organ injuries.

		Transfusion requirement (%)			Units pRBC			Units FFP		
Author, year		AC/AP Yes	No	*p*	AC/AP Yes	No	*p*	AC/AP Yes	No	*p*
Bhattacharya et al., 2021	[18]	26.5 %	26.4 %	ns	5.7 (5.6)[b]	8.0 (10.3)[b]	***	3.9 (5.0)[b]	5.4 (8.6)[b]	***
Bhattacharya et al., 2020	[17]	58 %	40.1 %	**	3.8 (4.2)[a]	5.7 (8.7)[a]	*	3.1 (4.0)[a]	3.2 (7.7)[a]	ns
Dougherty et al., 2019	[19]	–	–	–	1.8	0.8	ns	–	–	–
Reina et al., 2022	[22]	–	–	–	3 [2–6][b]	3 [2–6][b]	ns	2 (0–4)[b]	2 (0–4)[b]	ns
Huang et al., 2021 (Liver arm)	[20]	–	–	–	7.8 (12.9)[c]	6.9 (12.4)[c]	ns	6.6 (17.1)[c]	6.0 (24.6)[c]	ns
Huang et al., 2021 (Spleen arm)	[20]	–	–	–	11.0 (13.4)[c]	10 (13.2)[c]	ns	4.3 (15.6)[c]	7.8 (15.6)[c]	ns
Huang et al., 2022	[21]	–	–	–	14.1 (20.8)	8.9 (17.4)[c]	**	12.0 (23.1)[c]	6.6 (18.4)[c]	**

-, not collected. *AC/AP,* anticoagulant or antiplatelet agent. *pRBC,* packed red blood cells. *FFP,* fresh frozen plasma.
ns, $p > 0.05$; *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.005$.
Statistical analyses in this table reflect analyses done by the original authors.
[a] Among those tranfused only.
[b] First 24 h only.
[c] Expressed in Taiwan units.

agents in current practice [24]. Moreover, though easier to use for the patient than historical agents, NOACs are more complex with respect to their therapeutic activity assays and reversal methods, which may impact management of the trauma victim [25,26]. Notably, NOAC use may be associated with worse outcomes in the setting of intracranial haemorrhage as compared to warfarin [27], though applicability of these findings in SOI may be limited. NOAC reversal methods are complex and evolving; while some NOACs such as dabigatran have (very costly) reversal agents available, many others do not [28]. Currently, there is limited information available on the use of reversal agents in the setting of solid organ trauma, with no studies included in this review discussing this topic. Further research should be conducted to better understand this subject by investigating the pre-injury use of NOACs in solid organ injuries.

It is unfortunate that half of the studies reviewed did not control for the major confounder of patient age. In all of the unmatched studies [17–19], the AC/AP group was significantly older than their non-AC/AP counterparts, which is to be expected as older age is associated with increasing AC/AP use [29]. Further, it is already established in the literature that older patients are generally predisposed to worse outcomes secondary to comorbidities, polypharmacy, and nutritional deficits [12,30,31]. Moreover, elderly patients are more likely to have ceilings of care limiting intervention [14], and be poorer operative candidates [32]. While confounding factors must be considered when interpreting the included studies, as existing literature on general trauma already comments on the increased likelihood of poorer outcomes in older patients for those on AC/AP therapy [11,28], it is possible that the effects seen in this review would be replicated within an age-controlled elderly group.

Table 4
Management in trauma patients sustaining solid organ injuries.

Author, year		Operative			Non-operative, including embolisation			Failure of non-operative management		
		AC/AP Yes	No	*p*	AC/AP Yes	No	*p*	AC/AP Yes	No	*p*
Bhattacharya et al., 2021	[18]	19.3 %	21.5 %	ns	89.7 % [a]	73.9 % [a]	*	–	–	–
Bhattacharya et al., 2020	[17]	13 %	24 %	*	38 %	20 %	***	7.1 %	3.5 %	ns
Dougherty et al., 2019	[19]	23.3 %	11.6 %	ns	36.7 % [b]	8.7 % [b]	**	20 %	0.7 %	*
Reina et al., 2022	[22]	–	–	–	–	–	–	4.5 %	2.6 %	**
Huang et al., 2021 (Liver arm)	[20]	20.6 %	22 %	ns	6.1 % [b]	6.1 % [b]	ns	–	–	–
Huang et al., 2021 (Spleen arm)	[20]	46.5 %	44.7 %	ns	11.5 % [b]	10.6 % [b]	ns	–	–	–
Huang et al., 2022	[21]	34.2 %	27.5 %	ns	16.3 % [b]	8.2 % [b]	**	–	–	–

Statistical analyses in this table reflect analyses done by the original authors.
ns, $p > 0.05$; *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.005$.
-, not collected. *AC/AP,* anticoagulant or antiplatelet agent.
[a] Rates of embolization among patients already undergoing angiography.
[b] Indicates embolization only; not indicative of patients with only medical management.

Strengths and limitations

This scoping review was guided by the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews PRISMA-ScR [15], and the search strategy was systematic, comprehensive, and included peer-reviewed articles. All studies that assessed the use of pre-injury anticoagulants or antiplatelet medications and injuries sustained through any traumatic mechanism were included.

However, this review is limited by the scarcity of the literature available on this topic satisfying the selection criteria. The small number of included studies makes this review more vulnerable to the effects of bias and/or limitations of each included study. Moreover, we acknowledge the heterogeneity within the datasets, which limits the ability to draw conclusions from this review. All of the studies included were limited by their retrospective and non-randomised designs. A formal assessment of quality was not undertaken for the included studies, in keeping with the scoping style of the review. This study is intended to demonstrate the breadth of available literature, demonstrate possible effects and/or trends, and identify how further research could be designed to help complete the picture.

Moreover, while focusing solely on solid organ injuries allows for elucidation of effects specific to the highly vascularised organs, it should be recognised that solid organ injuries often do not occur in isolation. Despite all except one study showing that injury severity did not differ significantly between AC/AP and non-AC/AP groups [18], the effects noted in each study are all influenced by the potential confounding effect of other injuries on outcomes.

Conclusion

In all, the current review has demonstrated increased rates of failure of non-operative management in patients on anticoagulant and antiplatelet therapy sustaining solid organ trauma; this group of patients is likely also likely to face worse post-injury outcomes. However, the data surrounding this topic is limited and heterogeneous, thus leaving more questions to be answered by further studies in specific clinical contexts, such as in elderly trauma patients.

Ethics statement

The authors declare that this manuscript has been produced in compliance with the Journal's published guidelines for ethics in research.

CRediT authorship contribution statement

Gi Young Seo: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Conceptualization. **Arpita Das:** Writing – review & editing, Validation, Supervision, Methodology. **Silvia Manzanero:** Writing – review & editing, Validation, Supervision, Methodology. **Keeyeon Kim:** Investigation. **Carl Lisec:** Writing – review & editing, Visualization, Supervision, Conceptualization. **Michael Muller:** Writing – review & editing, Visualization, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2025.112175.

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