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One in Four Patients with Gastrointestinal Bleeding Develops Shock or Hemodynamic Instability: A Systematic Review and Meta-analysis

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Abstract

BACKGROUND

Hemodynamic instability and shock are associated with untoward outcomes in gastrointestinal bleeding. However, there are no studies in the existing literature on the proportion of patients who developed these outcomes after gastrointestinal bleeding.

AIM

To determine the pooled event rates in the available literature and specify them based on the bleeding source.

METHODS

The protocol was registered on PROSPERO in advance (CRD42021283258). A systematic search was performed in three databases (PubMed, Embase, and CENTRAL) on 14th October 2021. Pooled proportions with 95% confidence intervals (CI) were calculated with a random-effects model. A subgroup analysis was carried out based on the time of assessment (on admission or during hospital stay). Heterogeneity was assessed by

Higgins and Thompson's I^2. The Joanna Briggs Institute Prevalence Critical Appraisal Tool was used for the risk of bias assessment.

RESULTS

We identified 11,589 records, of which 220 studies were eligible for data extraction. The overall proportion of shock and hemodynamic instability in general gastrointestinal bleeding patients was 0.25 (CI: 0.17–0.36, I^2 = 100%). In non-variceal bleeding, the proportion was 0.22 (CI: 0.14–0.31, I^2 = 100%), whereas it was 0.25 (CI: 0.19–0.32, I^2 = 100%) in variceal bleeding. The proportion of patients with colonic diverticular bleeding who developed shock or hemodynamic instability was 0.12 (CI: 0.06–0.22, I^2 = 90%). The risk of bias was low, and heterogeneity was high in all analyses.

CONCLUSION

One in five, one in four, and one in eight patients develops shock or hemodynamic instability on admission or during hospitalization in the case of non-variceal, variceal, and colonic diverticular bleeding, respectively.

Key Words: Gastrointestinal bleeding; Hemodynamic instability; Shock; Meta-analysis; Statistics; Review

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Core Tip: Gastrointestinal bleeding is one of the most common gastrointestinal emergencies with estimated mortality up to 10%. It is associated with significant morbidity, additional burden, and health care costs. It is documented that hemodynamic instability and shock are highly associated with untoward outcomes;

they lead to a higher mortality rate, rebleeding risk, prehospital transfusion, and sedation complications. Our study provides clear evidence that hemodynamic instability and shock are common presentations and complications in gastrointestinal bleeding and gives insight into some possible predictor factors.

INTRODUCTION

The annual incidence of gastrointestinal bleeding (GIB) is 100 per 100,000 population, and it is one of the most common gastroenterological emergencies with an estimated mortality rate in the range of 2-10%, primarily due to complications related to the admission state and individual patient factors[1, 2]. It is associated with significant morbidity, additional burden, and health care costs[3, 4]. The mortality rate of upper GIB has not considerably decreased over the past decades, despite the improvement in the diagnosis and endoscopic treatment[5]. We contemplate that pre-endoscopic assessment and post-endoscopic care may contribute effectively to better outcomes.

Several studies showed that hemodynamic instability (HI) and shock in GIB are highly associated with untoward outcomes; they can lead to higher mortality rates, prehospital transfusion, rebleeding risk, and endoscopic sedation might be complicated with unfavorable hemodynamics if the patient presents with massive bleeding[6-8]. Furthermore, the hospital mortality rate of bleeding with shock can be 10 times higher than without shock[9].

Early intensive resuscitation of HI decreases complications in patients with upper GIB[10]. However, there are not enough details in the guidelines regarding the management of hemodynamically unstable patients; there are still some uncertainties about the optimal fluid rate and the ideal type of fluid to be used in treating those patients[11].

At the time of our systematic search, there were no published systematic reviews assessing the proportion of hemodynamically unstable and shocked patients in GIB. There are large variations in the proportions of these outcomes. Some studies in variceal and non-variceal bleeding resulted in proportions of 10% or lower[12-15], whereas others exceeded 60%[16-18]. Therefore, we aimed to highlight the importance of recognizing those patients by quantifying the pooled event rates based on the bleeding source. Additionally, we did a subgroup analysis based on the assessment time of these outcomes (on admission or during hospital stay).

MATERIALS AND METHODS

Our systematic review and meta-analysis was conducted following the recommendation of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guideline[19]. The recommendations of the Cochrane Handbook were also followed[20]. The study protocol was registered on PROSPERO (CRD42021283258), and we fully adhered to it[21].

Eligibility criteria

We applied the CoCoPop (condition, context, and population) framework to establish the eligibility criteria[22]; the condition was hemodynamic instability and/or shock, gastrointestinal bleeding as a context, and our population was adult patients. All definitions of hemodynamic instability and shock were accepted.

Randomized Controlled Trials (RCTs), cohorts, and case-control studies were included. Cross-sectional studies were included only if the hemodynamic parameters were assessed on admission. We included studies only if the primary cause of hospital admission was gastrointestinal bleeding and excluded articles that assessed our investigated outcomes after specific interventions. Articles that could not be found were sought for retrieval by contacting the journals and the authors. In the case of studies with overlapping populations, we kept the ones with larger sample sizes.

Information sources

Our systematic search was conducted in three main databases: MEDLINE (via PubMed), Embase, and Cochrane Central Register of Controlled Trials (CENTRAL) from the inception to 14th October 2021. No language or other restrictions were applied.

Search strategy

Our search key contained two main concepts: all types of bleeding sources and hemodynamic instability or shock. For the detailed search strategy, see Supplementary Table 1.

Screening and selection

Following the systematic search, the yielded articles were imported into a reference management program (EndNote 20.1). Duplicate articles were eliminated automatically and manually with overlapping publication years, authors, and titles. The screening and selection were performed by two independent reviewers (M.O. and E.T.) first by title and abstract, and then by full text (considering the eligibility criteria). Cohen's kappa coefficient (κ) was calculated at both levels of selection to measure the inter-reviewer reliability. In case of any disagreement, a consensus was reached after a discussion with the corresponding author (B.E.).

Data extraction

The relevant data from the eligible studies were extracted independently by two authors (M.O. and A.R.). Disagreements were resolved by involving the corresponding author (B.E.). All data were manually collected and introduced into an Excel spreadsheet (Office 365, Microsoft, Redmond, WA, USA) for analysis. The following data were extracted: first author, the year of publication, Digital Object Identifier, geographical location, study period and design, number of centers, basic demographics, source of bleeding, the total number of GIB patients and those who developed HI or

shock, definitions of the investigated outcomes, and the time of detection (on admission or during hospital stay).

Risk of bias assessment and quality of evidence

Two independent authors (M.O. and E.T.) performed the risk of bias assessment using the 'Joanna Briggs Institute Prevalence Critical Appraisal Tool'[22]. A third reviewer resolved potential disagreements (A.R.). The tool contains nine items regarding the target population and study settings. Each item was rated as 'yes', 'no', 'unclear', or 'not applicable' according to information provided in each study, with a maximum score of nine points. The higher the score, the lower the risk of bias.

We followed the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach[23] to evaluate the quality of evidence of our results, and the GRADEpro tool (software) was used. Study design, risk of bias, inconsistency, indirectness, and imprecision were the determinant factors.

Statistical synthesis

The statistical analysis of the data was conducted by the R programming language using the meta package. We used forest plots to summarize the findings of the studies and show the pooled result. Pooled event rates were calculated with 95% confidence intervals (CIs). The random-effect model was anticipated as applied in all analyses as considerable between-study heterogeneity. The random intercept logistic regression model method was used for pooling method as recommended by Schwarzer *et al*.[24]. To estimate the heterogeneity variance measure τ^2, the maximum likelihood method was used. For the outcomes where the study number was at least five, a Hartung-Knapp adjustment was used[25, 26]. Below five studies, we applied the adjustment if it was more conservative than without the adjustment. Statistical heterogeneity was assessed by Higgins and Thompson's I^2[27].

Egger's test with the Peter's modification and funnel plots were applied to report and visualize publication bias if at least 10 studies were involved in the analysis[28]; $P < 0.1$ indicates potential publication bias. We also performed an influential sensitivity analysis with leave-one-out method to evaluate whether a single study could have a marked influence on the overall proportional rate or heterogeneity.

A subgroup analysis was carried out based on the time of assessment (on admission or during hospitalization) of HI or shock. Studies where there were no data about the time when the patients were assessed, were considered (during hospitalization). We used a fixed-effects "plural" model. We assumed that subgroups had different τ^2 values as we anticipated differences in the between-study heterogeneity in the subgroups, although a common τ^2 assumption was used for practical reasons if the subgroup size was maximum five. To assess the difference between the subgroups, a Cochrane Q test was used between subgroups[29]. We did not calculate the overall effect and heterogeneity for subgroups where less than three studies were included. We calculated the prediction intervals for our outcomes to assess the probability that future studies would have the same result in a similar setting[30]. The statistical methods of this study were reviewed by Dániel Sándor Veres who is a verified biostatistician from the Centre for Translational Medicine, Semmelweis University.

RESULTS

Search and selection

Altogether, 11589 studies were identified by our search key through three main databases, 8129 in Embase, 3134 in MEDLINE (via PubMed), and 326 in CENTRAL. Of them, 9192 records remained for title and abstract selection after duplicate removal. A total of 601 studies were sought for full-text selection, out of which 164 records were not found. We managed to retrieve 29, but 135 records were still inaccessible. In total, 466 studies were assessed for full-text eligibility, of which 246 were excluded (Supplementary Table 2). Eleven studies were removed for overlapping populations

(Supplementary Table 3). Details of search and selection are illustrated in the PRISMA 2020 flow chart (Figure 1).

Basic characteristics of included studies

Most of the included studies were cohort studies. We also included 28 RCTs, 6 case-control, and 4 cross-sectional studies. Eighty records were from Asia, 66 from Europe, 25 from North America, and 13 from Africa. In total, more than six million patients were included in the analysis. However, the study with the largest sample size included 6,411,838 patients with different bleeding sources from a 12-year national analysis in the United States[9]. The main characteristics of the enrolled studies are detailed in Supplementary Table 4.

Hemodynamic instability and shock in general gastrointestinal bleeding sources.

We included all studies with unspecified bleeding sources. HI was assessed on admission and during hospital stay with pooled event rates of 0.29 (CI: 0.12 – 0.56, I^2 = 87%) and 0.34 (CI: 0.11 – 0.68, I^2 = 93%), respectively. Shock on admission was 0.27 (CI: 0.08 – 0.60, I^2 = 92%), whereas during hospital stay it was 0.15 (CI: 0.05 – 0.36, I^2 = 99%). One in four patients with GIB developed HI or shock; 0.25 (CI: 0.17 – 0.36, I^2 = 100%). (Figure 2)

Hemodynamic instability and shock in non-variceal upper GIB

In the case of non-variceal bleeding, more than three million patients were included in the analysis. The proportion of hemodynamically unstable patients on admission was 0.21 (CI: 0.12 – 0.36, I^2 = 97%). Two studies assessed HI during hospitalization, Hwang *et al.*[31] and Kwon *et al.*[32] where the event rate was 0.10 (CI: 0.08 – 0.11) and 0.57 (CI: 0.42 – 0.70), respectively. Moreover, shock on admission was the highest at 0.36 (CI: 0.21 – 0.53, I^2 = 98%), with a noticeable difference from those who developed shock during hospitalization with a rate of 0.07 (CI: 0.02 – 0.18, I^2 = 100%). Altogether, 0.22 (CI: 0.14 –

0.31, I^2 = 100%) of non-variceal bleeders developed shock or HI on admission or during the hospital stay. (Figure 3)

Hemodynamic instability and shock in variceal upper GIB

The rate of patients with variceal bleeding who presented with HI on admission was 0.38 (CI: 0.12 – 0.73, I^2 = 98%). Two studies assessed HI during hospitalization, Farooqi *et al.*[33] and Choi *et al.*[34] where the event rate was 0.21 (CI: 0.14 – 0.29) and 0.52 (CI: 0.40 – 0.63), respectively. The shock rate on admission was 0.26 (CI: 0.18 – 0.36, I^2 = 100%), whereas it was 0.18 (CI: 0.10 – 0.30, I^2 = 99%) during the hospital stay. In total, one in four patients with variceal bleeding developed shock or HI at presentation or during hospital stay 0.25 (CI: 0.19 – 0.32, I^2 = 100%). (Figure 4)

Hemodynamic instability and shock in peptic ulcer bleeding

Peptic ulcer bleeding (PUB) was the most reported source of bleeding among the included studies. Sixty-seven studies were involved in the subgroups. On admission, 0.22 (CI: 0.09 – 0.44, I^2 = 96%) of the patients were hemodynamically unstable, whereas during the hospital stay, it was 0.41 (CI: 0.12 – 0.78, I^2 = 89%). The rate of shock on admission was 0.25 (CI: 0.19 – 0.32, I^2 = 98%), whereas 0.24 (CI: 0.17 – 0.33, I^2 = 97%) developed shock during hospitalization. As an overall effect, one in four PUB patients was affected by HI or shock on admission or during hospital stay; 0.25 (CI: 0.21 – 0.30, I^2 = 98%). (Supplementary Figure 1)

Hemodynamic instability and shock in upper GIB

The studies included in this plot contain various upper GIB sources. All the studies that reported HI were assessed on admission, with a rate of 0.33 (CI: 0.21 – 0.48, I^2 = 97%). Seventeen studies were included in the shock on admission subgroup with a rate of 0.15 (CI: 0.09 – 0.25, I^2 = 99%), whereas 18 studies evaluated shock during hospitalization with a rate of 0.20 (CI: 0.12 – 0.32, I^2 = 100%). In total, one in five patients with upper GIB developed shock or HI; 0.20 (CI: 0.15 – 0.27, I^2 = 100%). (Supplementary Figure 2).

Hemodynamic instability and shock in lower GIB

Thirteen studies evaluated HI in lower GIB population: three studies on admission with a rate of 0.14 (CI: 0.01 – 0.81, I^2 = 83%), and 10 studies during hospitalization with a rate of 0.49 (CI: 0.27 – 0.71, I^2 = 94%). Two studies assessed shock on admission, Oakland *et al.* [35] and Li *et al.*[36] where the pooled event rates were 0.02 (CI: 0.02 – 0.03) and 0.03 (CI: 0.03 – 0.03), respectively. Another two studies assessed shock during hospital stay. In the study by Siddiqui *et al.* [9] the shock rate was 0.02 (CI: 0.02 – 0.02). The study by Lv *et al.*[37], which involved patients with life-threatening bleeding, resulted in the highest pooled event rate of shock with a rate of 0.68 (CI: 0.50 – 0.82). In total, of the general lower GIB population, 0.27 (CI: 0.13 – 0-49, I^2 = 100%) developed shock or HI. (Figure 5)

Hemodynamic instability and shock in colonic diverticular bleeding

All studies assessed the investigated outcomes on admission only. Six studies evaluated shock in colonic diverticular bleeding (CDB) with a rate of 0.12 (CI: 0.05 – 0.26, I^2 = 91%). Only two studies reported HI, that of Gilshtein *et al.*[38] reported a rate of 0.05 (CI: 0.02 – 0.11), and Ichiba *et al.*[39] a rate of 0.21 (CI: 0.17 – 0.26). As an overall effect, the proportion of shock and HI in CDB was 0.12 (CI: 0.06 – 0.22, I^2 = 90%). (Supplementary Figure 3)

Risk of bias assessment

Most of the studies received a score of 6 or higher, indicating a moderate to low risk of bias. Only 10 studies were rated with a score less than six. The sample size was not adequate in 33 studies. The results of the risk of bias assessment are presented in Supplementary Table 5.

Heterogeneity and publication bias

Serious heterogeneity (with more than 80%) was observed in all our analyses. The large number of included studies with heterogeneous populations regarding age and sex

could explain this. The definitions of HI and shock in the studies were not the same resulting in considerable heterogeneity, too.

All of our meta-analytical calculations that included 10 or more studies were investigated for publication bias. CDB was an exception where only eight studies were included. We found potential publication bias in all of our analyses except for non-variceal bleeding based on Egger's test. This result could be explained by the very large heterogeneity of the study estimates. Additionally, a highly influential large study by Siddiqui *et al*.[9] led to a false positive result for Egger's test.

Leave-one-out sensitivity analysis showed some variability for some potential outliers. The proportion of our outcomes changed from 0.25 (CI: 017 – 0.36, I^2 = 100%) to 0.29 (CI: 0.22 – 0.37, I^2 = 90%) if Siddiqui *et al*.[9] study was eliminated from the GIB analysis. This study did not only include a large sample size compared to other studies but also used the National Inpatient Sample database using ICD-9 codes to analyze patient data, which might have failed to identify some affected patients. Results of Egger's test, funnel plots, and leave-one-out analysis are found in Supplementary Figures 4-16.

Certainty of evidence

Based on the results and the careful evaluation of the evidence level, the certainty levels were low or very low for each outcome. The very high heterogeneity in almost all analyses was the main reason for that. In addition, all the included studies were considered observational studies, which contributes to the low level of evidence. (Supplementary Tables 6-12).

DISCUSSION

Our study found that HI and shock are common complications of GIB. Either shock or HI affects one in every four patients; even the lowest proportion, one in eight colonic diverticular bleeders, is still a significant portion of patients.

Variceal bleeding resulted in the highest HI on admission, with a rate of (38%) among various bleeding sources. In contrast, the highest HI rates during hospitalization were observed in PUB (41%) and LGIB (49%). The rate of shock on admission was generally the highest among different non-variceal bleeding sources (36%), whereas PUB specifically led to the highest rate of shock during hospitalization (24%).

Our results about unspecified GIB sources, non-variceal, and PUB showed higher rates of HI during hospitalization than on admission and higher rates of shock on admission than during hospitalization. In contrast, variceal bleeding showed higher rates of HI and shock on admission than during hospitalization. Lower GIB, on the other hand, showed higher rates of these outcomes during hospitalization than on admission.

Blood loss leads to HI characterized by a decrease in systolic blood pressure (BP) and an increase in heart rate (HR). Eventually, it can lead to a more severe state of shock, which is caused by a rapid reduction of intravascular blood volume resulting in decreasing hemoglobin levels, thereby decreasing the oxygen delivery capacity of the heart. HI is not just a sign; it is the starting point of a chain of events leading to hypoxemia and hypoperfusion. If it is not appropriately treated as soon as possible, it will lead to multiple organ failures. Therefore, health care providers must emphasize continuous monitoring and efficient stabilization for those patients[10].

Serious heterogeneity was observed in all our analyses. The reason for this lies in the large number of included articles. The population had different geographical locations, ethnicities, several comorbidities, age ranges, and access to different qualities of health care systems. Thus, there was even a variation in the definitions; most of the included studies defined HI as a decrease of systolic BP < 100 mmHg and/or an increase in HR > 100 bpm[6]. However, some definitions included syncope, orthostatic changes[39], or signs of organ hypoperfusion[40]. All these factors contributed noticeably, resulting in a

very serious heterogeneity. All definitions of HI and shock can be found in Supplementary Table 13 and Table 14, respectively.

Possible predictors were observed that resulted in higher rates of our investigated outcomes. We observed some outliers in different sources of bleeding; in variceal bleeding, intensive care unit admission[41-43], elderly population[16], and severe uncontrolled bleeding[34] were possible predictors for higher rates of shock and HI. In non-variceal bleeding, elderly patients > 60 years[16] and those who underwent embolization[32] accounted for the highest rate of HI on admission and during hospitalization, respectively. As for upper GIB in general, the study by Chirapongsathorn *et al.*[17] included variceal and non-variceal bleeders, where they defined shock as mean arterial pressure lower than 50 mmHg, which results in a very high rate of shock (75%).

Lower GIB is three times less common than upper GIB and has not been the focus of much attention yet. Mortality rises to 20-40% in the case of massive lower GIB complicated by unstable hemodynamics[44]. Super-selective patients who underwent arterial embolization[45], angiography[46], or were diagnosed with acute severe bleeding[47] showed higher rates of the investigated outcomes.

Strengths and Limitations

This is the first comprehensive overview to assess the proportion of patients affected by HI and shock in GIB and specify it according to the bleeding source. Our study included many studies with an extensive sample size. Additionally, subgroup analysis, which was based on the time of assessment, whether on admission or during hospital stay, provided a more precise overview. This study also gives an insight into some of the possible predictors that result in higher rates of our investigated outcomes.

Considering the limitations of this work, the definitions of HI and shock were different among the included studies or even missing. Different characteristics of the included population led to high heterogeneity in almost all analyses. The presence of low certainty of evidence in some domains is another limitation.

Implications for practice and research

Based on our results, we suggest standardizing the definition of HI and shock, and establishing a protocol to proactively screen and monitor the affected patients in routine management. Physicians involved in the treatment of the affected patients should focus more on early and rapid correction of hemodynamics because it significantly decreases mortality[10]. Therefore, a careful pre-endoscopic assessment and strong adherence to risk stratification scores need to be highlighted. Furthermore, cautious care and continuous monitoring of the affected patients should be emphasized, especially for high-risk patients.

CONCLUSION

Our study has provided clear evidence that hemodynamic instability and shock are common presentations and complications of GIB. On the basis of our findings, a high majority of patients are affected; one in five, one in four and one in eight patients develops shock or hemodynamic instability on admission or during the hospital stay in the case of non-variceal, variceal, and colonic diverticular bleeding, respectively. Patients need a more proactive treatment strategy and require continuous monitoring to prevent untoward outcomes.

ARTICLE HIGHLIGHTS

Research background

Hemodynamic instability (HI) and shock are associated with unfavorable outcomes in gastrointestinal bleeding (GIB). Understanding the proportion of these outcomes is essential for several reasons. Firstly, it provides valuable insight into the severity and

potential risks associated with the condition. Knowing the proportion of patients who develop shock or HI helps healthcare providers anticipate the need for immediate interventions and allocate appropriate resources accordingly.

Research motivation

At the time of our systematic search, there was no data in the current literature describing these proportions in GIB based on the bleeding source. Additionally, monitoring changes in these patients over time can serve as an indicator of the effectiveness of medical interventions and guide future treatment strategies to improve patient outcomes.

Research objectives

Our aim is to quantify the pooled event rates of HI and shock in GIB. This will help in risk stratification and determining the overall severity of the condition. By understanding how frequently these outcomes occur, healthcare providers can identify high-risk patients who require immediate and intensive management.

Research methods

We conducted a systematic review with meta-analysis to determine the proportions of HI and shock in different GIB sources. The R programming language, using the meta package, was employed to perform statistical analysis on the data. Forest plots were utilized to summarize the study findings and present the results. Pooled event rates with 95% confidence intervals (CIs), were computed to provide a measure of the overall outcomes.

Research results

The overall proportion of HI and shock was found to be 25% across all sources of GIB, 22% in non-variceal bleeding, 25% in variceal bleeding, and 12% in colonic diverticular bleeding. However, our findings also revealed a high degree of heterogeneity,

highlighting the significance of our study. This heterogeneity suggests a lack of consensus in the guidelines in this field, as evidenced by the varied definitions of our included outcomes.

Research conclusions

Our study provides compelling evidence that HI and shock are frequently observed complications and presentations in GIB. One in four patients with GIB develops shock or HI on admission or during the hospital stay.

Research perspectives

Given our findings, we recommend the establishment of a standardized definition for HI and shock in GIB. Additionally, implementing a protocol for proactive screening and continuous monitoring of affected patients should be considered as part of routine management. Emphasizing a thorough pre-endoscopic assessment and strict adherence to risk stratification scores is crucial. Furthermore, rigorous care and attentive monitoring should be emphasized, particularly for high-risk patients.

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