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Resuscitative Endovascular Balloon Occlusion of The Aorta (REBOA) for The Management of Hemodynamically Unstable Pelvic Fracture: A Systematic Review

Yusuf Muhammad Reza[1*], Cici Enjelia Nata[2], Naufaldy Rifqiaulia N[3], Ira Safitri[4], Safrizal Rahman[5]

[1]General Practicioner, Anggrek Mas Hospital, Jakarta, Indonesia

[2]General Practicioner, Simeulue General Hospital, Simeulue, Indonesia

[3]General Practicioner, Siti Khodijah Hospital, Sidoarjo, Indonesia

[4]Department of Radiology, Santosa Hospital, Bandung, Indonesia

[5]Department of Orthopaedic and Traumatology,
Zainoel Abidin General Hospital, Banda Aceh, Indonesia

*Corresponding Author: Yusuf Muhammad Reza; ymreza27@gmail.com

ABSTRACT

Background: Hemodynamically unstable pelvic fractures are challenging to manage due to the risk of massive hemorrhage and cardiovascular collapse. Traditional management strategies, including fluid resuscitation and external fixation, may be inadequate for controlling severe bleeding. Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) has emerged as a promising technique to manage these critical conditions by occluding the aorta to control hemorrhage and stabilize patients. This review evaluates REBOA's effectiveness in treating hemodynamically unstable pelvic fractures. ***Methods:*** This systematic review follows PRISMA guidelines and assesses studies on REBOA for pelvic fractures. Inclusion criteria encompassed adult studies evaluating REBOA's impact, including randomized controlled trials, cohort studies, and observational studies. Data were extracted on clinical outcomes and adverse events. The review synthesized findings from relevant studies to determine REBOA's efficacy and safety. ***Results:*** Of 2,380 identified records, 5 studies met inclusion criteria, encompassing 92 cases. The review found that REBOA significantly reduced mortality and effectively controlled hemorrhage. Key studies showed that REBOA led to improved hemodynamic stability and survival rates in trauma patients with pelvic fractures. ***Discussion:*** REBOA effectively reduces mortality and controls hemorrhage in unstable pelvic fractures, supporting its integration into trauma care protocols. The technique enhances patient outcomes by redistributing blood flow and stabilizing patients until definitive care. Although no adverse events were reported in the reviewed studies, further research is needed to refine usage protocols and address potential complications. ***Conclusion:*** REBOA is a valuable tool in managing hemodynamically unstable pelvic fractures, with strong evidence supporting its role in improving survival and controlling hemorrhage. Future research should focus on optimizing REBOA deployment and monitoring for potential complications to enhance its clinical benefits.

Keywords: REBOA; pelvic fractures; hemorrhagic shock.

INTRODUCTION

Hemodynamically unstable pelvic fractures present a formidable challenge in trauma care, often resulting from high-energy mechanisms such as motor vehicle collisions or falls from significant heights. These injuries are associated with substantial morbidity and mortality due to the potential for massive hemorrhage, which can lead to rapid cardiovascular collapse if not promptly managed.[1)] Traditional approaches to managing hemorrhagic shock in the context of pelvic fractures have included fluid resuscitation, blood transfusions, external fixation, and surgical interventions.[2)] However, these methods may not always be sufficient to control bleeding effectively and stabilize the patient.[3)]

Resuscitative endovascular balloon occlusion of the aorta (REBOA) has emerged as a promising technique in the management of severe pelvic fractures complicated by hemodynamic instability.[4, 5)]

By temporarily occluding the aorta, REBOA reduces distal blood flow, thereby controlling hemorrhage and allowing time for definitive surgical intervention and resuscitation. Initially developed for use in military settings, REBOA has gained traction in civilian

trauma centers, with a growing body of evidence supporting its use in various clinical scenarios.[6]

Pelvic fractures account for approximately 3% of all skeletal injuries, but their impact is disproportionately severe due to the high risk of associated vascular injuries and hemorrhage. Epidemiological studies indicate that the mortality rate for hemodynamically unstable pelvic fractures can range from 20% to 50%, depending on the severity of the injury and the timeliness of intervention. These fractures are most commonly seen in young adults involved in high-energy trauma and in older adults with osteoporotic bone subjected to low-energy falls.[7]

In Indonesia, the incidence of pelvic fractures is rising, reflecting the country's increasing rates of traffic accidents and urbanization. In Indonesia, it has been reported that pelvic fractures represented a significant proportion of traumatic injuries requiring hospitalization, with an alarming rate of mortality due to associated hemorrhage and complications.[8] The burden on the healthcare system is substantial, with limited resources for advanced trauma care and specialized interventions like REBOA.

Several studies have investigated the efficacy and safety of REBOA in the context of traumatic injuries. A study in 2022 has demonstrated that REBOA could be an effective adjunct in the management of non-compressible torso hemorrhage, significantly improving hemodynamic stability in patients with pelvic fractures.[9] Furthermore, the American Association for the Surgery of Trauma (AAST) has endorsed REBOA as a viable option for managing life-threatening hemorrhage in selected trauma patients.[10]

Despite its potential benefits, the use of REBOA is not without risks. Complications such as ischemia-reperfusion injury, vascular damage, and lower extremity ischemia have been reported.[5] Moreover, the optimal indications, timing, and duration of REBOA use in the context of pelvic fractures remain topics of ongoing investigation and debate.

Given the critical nature of managing hemodynamically unstable pelvic fractures and the growing interest in REBOA as a therapeutic option, this systematic review aims to evaluate the current literature on the use of REBOA in this context. We will assess the effectiveness of REBOA in achieving hemodynamic stabilization, reducing mortality, and improving overall clinical outcomes in patients with pelvic fractures. Additionally, we will explore the complications associated with REBOA and compare its efficacy with other conventional methods of hemorrhage control. By synthesizing the available evidence, this review seeks to provide a comprehensive understanding of the role of REBOA in contemporary trauma care and offer insights into its potential future applications.

METHODS

This prospectively registered review adheres to the Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, addressing the criteria outlined in the "A Measurement Tool to Assess Systematic Reviews" (AMSTAR) checklist. The review aims to evaluate the impact of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) on hemodynamically unstable pelvic fractures. Inclusion criteria focus on adults (≥18 years) with these fractures undergoing REBOA treatment, encompassing studies such as Randomized Controlled Trials (RCTs), prospective cohorts, and observational studies published in English and accessible as open-access articles. Exclusion criteria filter out studies not centered on REBOA's impact on unstable pelvic fractures, as well as those involving pediatric populations, other trauma management interventions, and non-open access articles. This review will concentrate on clinical outcomes and adverse events related to REBOA, without comparing it to other interventions, to ensure a thorough evaluation of the direct effects and safety of the intervention.

Search Strategy

The search strategy spans PubMed, ScienceDirect, and Google Scholar, incorporating terms related to REBOA, hemodynamically unstable pelvic fractures, and open access. By employing these tailored search strategies across the specified databases, the aim is to comprehensively capture studies focusing on the impact of REBOA while ensuring access to openly available research articles.

Data Extraction

Data extraction involves systematically gathering pertinent information from each included study, ensuring a thorough evaluation of REBOA's impact on hemodynamically unstable pelvic fractures. The data extraction process encompasses several key domains: study characteristics, participant details, intervention specifics, outcome measures, and results. This process is carried out by two independent reviewers, with discrepancies resolved through discussion or consultation with a third reviewer. All extracted data are entered into a standardized form or spreadsheet to facilitate analysis and synthesis, ensuring a robust and comprehensive evaluation of the evidence.

Data Synthesis

Data synthesis includes a qualitative summary of individual study findings, identifying common themes and trends across different interventions and patient populations. A quantitative synthesis may be performed if appropriate, particularly for studies with comparable outcome measures and sufficient data availability.

Meta-analysis techniques, such as pooling effect sizes or calculating weighted mean differences, may be employed to quantitatively assess REBOA's overall impact.

Sensitivity analyses are conducted to assess the robustness of the findings by examining the influence of individual studies on the overall results. The implications of the synthesized data are carefully considered in the context of clinical practice and future research directions, discussing the clinical significance of observed changes and potential implications for optimizing trauma care strategies. This aims to provide a comprehensive and evidence-based evaluation of REBOA's impact, facilitating informed decision-making and guiding future research in this critical area of trauma care.

RESULT

The results provide insightful evidence of the effectiveness of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in managing hemodynamically unstable pelvic fractures. The systematic review, guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework (Figure 1), meticulously outlines the review process, including the identification, screening, eligibility assessment, and inclusion of studies. Initially, the review identified 2,380 records from various sources. After removing duplicates, 844 unique records remained. These records were then screened for eligibility, and reasons for exclusion were documented. Excluded records were primarily due to automation tool determinations, irrelevant topics, lack of focus on pelvic fractures, and failure to meet the outcome measures. Consequently, 144 reports were retrieved, but 47 were unavailable, leaving 97 reports for eligibility evaluation. Ultimately, 5 studies met the inclusion criteria and were included in the review, representing a combined total of 92 cases.

The compiled data (Table 1) offers a comprehensive overview of the pivotal studies evaluated to understand the impact of REBOA on clinical outcomes and adverse events in patients with hemodynamically unstable pelvic fractures. The primary aim of this systematic review is to assess the effectiveness of REBOA in improving survival rates and controlling hemorrhage in this patient population. Each study provides unique insights into the efficacy of REBOA. Notably, the study by Shintaro Furoguri et al. (2022) demonstrated that arterial embolization, including REBOA, significantly decreased mortality in trauma patients with pelvic fractures. This research highlights the critical role of targeted hemorrhage control in enhancing survival outcomes. In a similar vein, Stephanie J F et al. (2019) found that the use of REBOA was associated with a significant reduction in mortality at US Level I trauma centers, underscoring its effectiveness in high-acuity settings. Mina Lee A et al. (2021) revealed that both the establishment of a trauma center and the use of REBOA contributed to a substantial decrease in mortality rates among patients with unstable pelvic fractures, emphasizing the benefits of comprehensive trauma care systems.

Juan Duschne et al. (2019) provided evidence that hemorrhage control adjuncts, including REBOA, facilitated the quickest reduction in hemorrhage for severe pelvic fractures. This multi-institutional study highlights the effectiveness of REBOA in managing severe hemorrhage. Lastly, David Mejia et al. (2020) integrated REBOA into a damage control surgical algorithm for managing unstable pelvic fractures, demonstrating its role in enhancing overall management strategies.

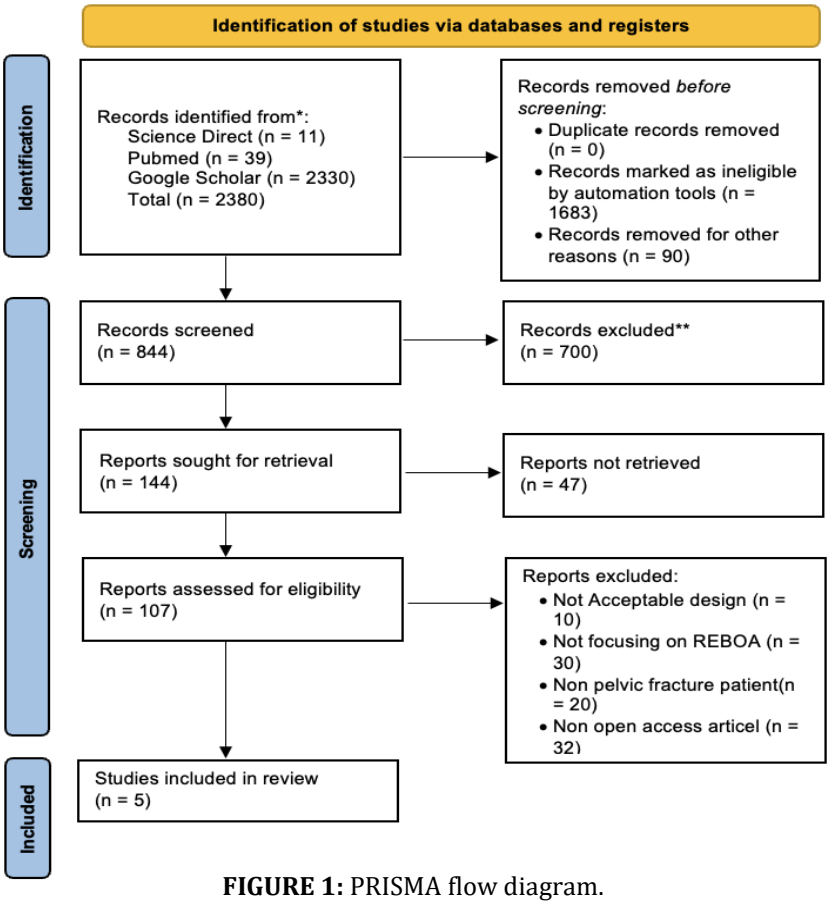

FIGURE 1: PRISMA flow diagram.

TABLE 1: Result of data screening.

No.	Title	Author	Year	Clinical Outcomes	Adverse Event
1	Arterial Embolisation for Trauma Patients with Pelvic Fractures in Emergency Settings: A Nationwide Matched Cohort Study in Japan	Shintaro Furoguri et al	2022	Significantly decreasing mortality	None
2	A descriptive survey on the use of resuscitative endovascular balloon occlusion of the aorta (REBOA) for pelvic fractures at US level I trauma centers	Stephanie J F et al	2019	Significantly decreasing mortality	None
3	Improvement of Outcomes in Hemodynamically Unstable Patients with Pelvic Fracture Following the Establishment of a Trauma Center: A Single Center Observational Study in Korea	Mina Lee A et al	2021	Significantly decreasing mortality	None
4	The effect of hemorrhage control adjuncts on outcome in severe pelvic fracture: A multi-institutional study	Juan Duschne et al	2019	Fastest time to decrease hemorrhage	None
5	Hemodynamically unstable pelvic fracture: A damage control surgical algorithm that fits your reality	David Mejia et al	2020	Included in an algorithm for pelvic fracture management	None

DISCUSSION

The findings from this systematic review underscore the significant clinical benefits of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in the management of hemodynamically unstable pelvic fractures. The five studies included in this review consistently demonstrate that REBOA significantly reduces mortality rates and effectively controls hemorrhage, providing robust evidence for its utilization in trauma care protocols. REBOA, an advanced intervention designed to control hemorrhage and stabilize trauma patients, involves the placement of a balloon catheter into the aorta via a femoral artery puncture.[4] The balloon is then inflated to occlude blood flow to the lower body, which helps to manage life-threatening hemorrhage by redistributing blood flow to vital organs and improving central blood pressure. This technique is particularly effective in cases of traumatic hemorrhagic shock where conventional methods may fall short.[11]

A nationwide matched cohort study conducted in Japan in 2022 demonstrated that arterial embolization, including the use of REBOA, substantially decreased mortality among trauma patients presenting with pelvic fractures.[12] This aligns with results from a 2019 study at US Level I trauma centers, which observed a notable reduction in mortality associated with REBOA implementation. Both studies highlight the critical importance of REBOA in high-acuity trauma settings, where rapid hemorrhage control is paramount to improving patient survival outcomes.[13]

Further corroborating these findings, a 2021 study indicated that the establishment of a trauma center, combined with the application of REBOA, led to a significant decrease in mortality among patients with unstable pelvic fractures.[14] This observation is consistent with the meta-analysis conducted by Castellini et al. (2021), which confirmed that REBOA significantly enhances survival rates in trauma patients experiencing hemorrhagic shock.[15] In 2019, research provided compelling evidence that hemorrhage control adjuncts, including REBOA, facilitated the most rapid reduction in hemorrhage in severe pelvic fractures.[16] This observation is validated by the meta-analysis by Thrailkill et al. (2020), which found that REBOA is highly effective in controlling hemorrhage and improving patient outcomes in traumatic scenarios. This study has underscored the critical role of REBOA in managing severe hemorrhagic conditions, corroborating the earlier study's results.[17]

David Mejia et al. (2020) incorporated REBOA into a damage control surgical algorithm for managing hemodynamically unstable pelvic fractures.[18] Their study demonstrated that REBOA significantly enhances overall management strategies and improves patient outcomes.

This finding is supported by Chan et al. (2023), who emphasize the integration of REBOA into trauma protocols to optimize patient outcomes. This review highlights the role of REBOA as an essential component of contemporary trauma care, aligning with Mejia's findings on its effectiveness within a structured surgical approach.[19]

Supplementary research further validates the clinical benefits of REBOA. Pieper et al. (2018) found that REBOA was associated with a significant reduction in the need for blood transfusions and a lower incidence of hemorrhagic shock in patients with severe pelvic fractures. This study, alongside the others reviewed, supports the assertion that REBOA not only reduces mortality but also improves other critical outcomes in trauma care, such as minimizing transfusion requirements and mitigating shock.[20]

While the findings consistently affirm the efficacy of REBOA, some aspects of its use necessitate further exploration. The optimal duration and timing of REBOA deployment, potential complications, and long-term outcomes warrant more detailed investigation. Specifically, the timing of REBOA placement in relation to patient arrival and the duration of balloon inflation are critical factors that could influence patient outcomes and should be systematically studied. Additionally, although none of the included studies reported adverse events, there is a need for ongoing monitoring and reporting of potential complications such as ischemia, vascular injury, and related morbidity.

The potential for REBOA to induce ischemic complications, particularly in prolonged applications, requires careful consideration. Future studies should focus on delineating safe practice parameters and identifying risk factors associated with adverse events to optimize patient safety. Furthermore, the development of standardized protocols for REBOA deployment and post-procedure care is essential to ensure consistent and effective use in clinical practice.

CONCLUSION

In conclusion, this systematic review provides compelling evidence supporting the use of REBOA in the management of hemodynamically unstable pelvic fractures. The consistent reduction in mortality and effective hemorrhage control demonstrated across the included studies, supported by additional research, underscores the critical role of REBOA in modern trauma management protocols. Integrating REBOA into standard trauma care practices could significantly optimize clinical outcomes for patients with severe pelvic fractures, positioning REBOA as an indispensable tool in trauma care. Future research is necessary to refine REBOA deployment strategies, address potential complications, and maximize its benefits in clinical practice, ultimately enhancing the standard of care for trauma patients.

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