

Foley Catheter Following Penetrating Neck Trauma. A Definitive Therapy to Stop the Bleeding?

Barbaro Ignacio Monzon¹, Willem Brinkert², Henrike Heitmann³,
Marius Dettmer⁴, Dietrich Doll^{3,5}, Ville Vänni^{6*}

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Abstract

Introduction: The incidence of penetrating neck injuries is experiencing an upward trend. Given that hemorrhaging stands as one of the most preventable causes of fatality in traumatic situations, the prospect of employing a foley catheter (FC) to manage bleeding following penetrating neck injuries has led to contemplation on its integration into standardized protocols for bleeding control (BC), both in pre-hospital and in-hospital settings. Furthermore, inquiries into establishing standardized schedules for its application have arisen.

Material and Methods: A meticulous search strategy was conducted utilizing the NCBI Medical Subject Heading (MeSH) term “foley*” and various combinations such as “foley” AND “trauma”; “foley” AND “neck”; “foley” AND “penetrating”; “catheter” AND “balloon” AND “trauma”; “gunshot” AND “neck”; “hemorrhage*” AND “neck” across multiple databases. These databases include MEDLINE, PubMed, PubMed Central, Scopus, Ovid, Embase, and the Cochrane Central Register of Controlled Trials (CENTRAL). Additionally, comprehensive searches using these terms were performed on Google, Google Scholar, and ResearchGate. The references cited in documents retrieved from these searches, covering 1833 to 2023, were thoroughly scrutinized.

Results: 15 relevant articles were identified, and pertinent data were extracted from these studies. Historically, the use of FC was confined to immediate bleeding control; however, it has now extended its application into prehospital, emergency room (ER), and intraoperative settings. The primary success rate of FC stands at n=229 out of 274 cases (84%). FC serves as a valuable tool to bridge the gap in time before reaching the ER or operating room (OR), facilitating necessary radiological studies or interventions, especially when more severe injuries necessitate prioritization. Typically, FC was retained for 24-48 hours, but instances of prolonged applications up to 240 hours have been documented. Notably, it includes the definitive management of venous neck bleeding injuries, contingent upon excluding significant arterial defects through CTA. Late rebleeding stands at a low rate of 6% (14 out of 229 cases).

Conclusion: Using FC is a pertinent strategy in managing neck injuries resulting from bleeding from penetrating wounds. Its substantial primary success rate in prehospital and ER phases surpasses the success rates achieved solely through pressure or chitosan dressing. Post-primary bleeding control, the presence of FC facilitates examinations and radiological interventions. Determining the optimal duration for FC placement remains a subject for consideration, leaning toward 2-3 days, if not longer. FC is progressively solidifying its role in Selective Non-Operative Management (SNOM) for hemorrhagic penetrating neck injuries. Consequently, a Foley catheter should be an essential tool in the possession of every prehospital and ER physician. Further delineation of criteria establishing the suitability of FC placement as definitive SNOM therapy for hemorrhagic penetrating neck injuries warrants consolidation.

Keywords: Penetrating trauma, neck injury, foley catheter, balloon occlusion, bleeding control, observation, SNOM

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* **Corresponding author:**
Ville Vänni MD

✉ ville.vanni@gmail.com

1 Department of Surgery, Steve Biko Academic Hospital, School of Medicine, Faculty of Health Sciences University of Pretoria, Trauma Unit Charlotte Maxeke Johannesburg Academic Hospital, Department of Surgery, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, SOUTH AFRICA

2 Department of Anaesthesiology and Pain Medicine, Isala Hospital, Zwolle, Teaching Hospital of the University of Groningen, NETHERLANDS

3 Pilonidal Sinus Research Group, Vechtaer Institut für Forschungsförderung, Vechta, GERMANY

4 Department of Trauma Surgery and Orthopaedics, Reconstructive and Hand Surgery, and Burn Medicine, German Armed Forces Central Hospital, Koblenz, GERMANY

5 Department of Procto-Surgery & Pilonidal Sinus, St. Marienhospital Vechta, Academic Teaching Hospital of the MHH Hannover, Vechta, GERMANY

6 Helsinki Trauma Unit, Helsinki University Hospital, FINLAND

Introduction

A catheter is a thin, flexible tube inserted into a body cavity, duct, or blood vessel to perform various medical procedures. It is derived from the Greek word **kathiénai** (**καθιέναι**), which means something that is inserted or let down. Catheters are flexible tubes or devices inserted into a body cavity, duct, or vessel to either remove or instill fluids. It may also be the pathway to introduce instruments, devices, or items. Catheters are commonly used in various medical procedures, including urinary catheters, cardiac catheters, and vascular catheters. Unwarrantedly, sometimes, they are occluded.

One of the earliest descriptions of catheter use comes from the ancient Greek physician Hippocrates (c. 460-375 BC), who mentioned using hollow tubes to relieve urinary retention. Early catheters were often rigid and made from silver or other metals.

The indigenous peoples of Central and South America, such as the Mayans and the Aztecs, were harvesting and using rubber derived from the latex sap of rubber trees as far back as 1600 BCE. They used it for various purposes, including making waterproof clothing, footwear, and balls for sports. However, in the 18th century, rubber became better known in Europe. Charles-Marie de La Condamine, a French scientist and explorer, is often credited with introducing rubber to Europe after his expedition to South America in the 1730s. He documented the indigenous use of rubber and brought samples back to France for further study. The commercial use of rubber, particularly in producing various rubber products, started gaining traction in the 19th century. Charles Goodyear's discovery of the vulcanization process in the mid-19th century significantly improved the properties of rubber and made it more durable and suitable for a wide range of applications. Dr. Frederic Foley, an American urologist, developed the Foley catheter in the early 1930s. Since then, a wide variety of uses have been seen for the device.

Typically, the Foley catheter has been used for the drainage of urine in the elderly, in the operative setting, in ICU patients, and numerous more. Soon, it was also used for other purposes, such as drainage of deep-lying septic collections [2]. Foley balloon inflation was used for diagnostic and therapeutic procedures to measure and dilate bladder neck stenosis. [3, 4]

The first report was published as early as 1965 when the FC was used to compress bleeding areas, as described by Mr. Smellie when he controlled post-hemorrhoidectomy bleeding with a Foley catheter and a pack.[5] Since then, the area of use has been widened considerably.

Gynecologists following vaginal surgery and consecutive bleeding inserted FC [6, 7] as well as in uncontrollable bleeding postpartum [8, 9] or past cervical and uterus surgery.[10-13]

This device has proven useful even in abdominal wall bleeding following elective non-bariatric[14] and bariatric[15] surgery.

The Trauma community realized the potential of balloon catheter occlusion as early as 1966. Pearce and colleagues described the control of bleeding from mediastinal penetrating wounds with a balloon catheter tamponade.[16]

One catheter was used intraoperatively in a pulmonary vein gunshot laceration, and the other in a stab heart wound. In both patients, the surgeons achieved temporary bleeding control with the inflated balloon introduced into the



Figure 1: Two Foley catheters in place in penetrating neck injury. The skin has been approximated temporarily with staples to prevent the catheters from sliding out. The Foley on the right side has been knotted to prevent accidental deflation before diagnostics and therapy.



Figure 2: Foley catheter in place. Please note presternal hematoma, indicating bleeding into the subcutaneous fascial plane.

traumatic defect till a suture could be done. Encouragingly, both patients survived.

Foley tamponade could be used alone or in combination with packs intraoperatively [5] and in humans as in human best friend: a dog.[17] Wheeler and Kovacic published a case report of a dog with a femoral bite injury leading to a life-threatening hemorrhage through a transected left femoral artery and vein. Because the bleeding could not be stopped, they inflated an FC, which controlled the hemorrhage. It was left in the wound till surgical revision of the injury in the OR achieved bleeding control.

We wondered how Foley catheters (FC) are used at present to cope with clinically intractable hemorrhagic situations - in penetrating neck bleeding (Figure 1, Figure 2)

Material and Methods

Literature research was done using the PRISMA flow diagram results[18] (Figure 1).

Search Strategy and Study Selection Criteria

To compile a comprehensive database related to foley catheter in trauma use, we conducted a systematic search for the NCBI Medical Subject Heading (MeSH) term “foley*,” as well as the combination of “foley” AND “trauma”; “foley” AND “neck”; “foley” AND “penetrating”; “catheter” AND “balloon” AND “trauma”; “gunshot” AND “neck”; “hemorrhage*” AND “neck” in the following databases: MEDLINE, PubMed, PubMed Central, Scopus, Ovid, Embase, and Cochrane Central Register of Controlled Trials (CENTRAL). Additionally, we performed searches using these terms in Google, Google Scholar, and ResearchGate.

We also scrutinized the references in the bibliographies of all documents retrieved through these searches. The retrieved documents encompassed a range of study types, including randomized and non-randomized trials, prospective and retrospective studies, and observational studies, such as cohort, case-

control, cross-sectional studies, and case reports, published from 1833 to 2023.

All authors (BIM, WB, MD, JD, DD, VV) reviewed the retrieved documents for adherence to the inclusion criteria, which required the documentation of definitive treatment with FC. We considered reports published in English, French, German, Italian, and Spanish and also included publications in other languages if they provided an English abstract detailing the definitive treatment. Exclusion criteria encompassed FC use in urogenital use. Additionally, unpublished data presented in review articles were considered.

Data Collection, Extraction, and Quality Assessment

All studies were analyzed and documented on paper. Transcribed data were then entered into a Microsoft Excel spreadsheet (Version 2016, Microsoft Corp., Redmond, WA) and subjected to verification to ensure accuracy.

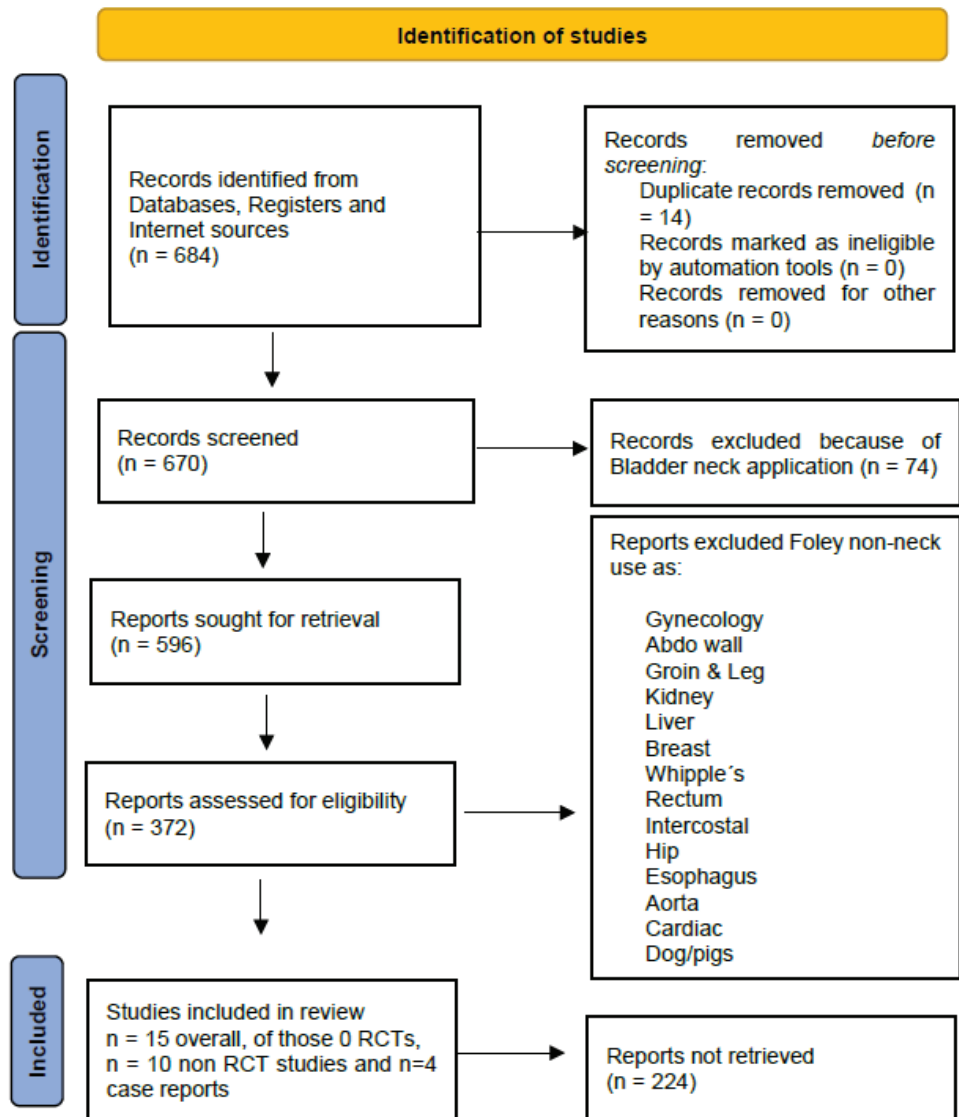


Figure 3. PRISMA flow chart of study harvest and qualification steps

Results

We observed a significant increase in the utilization of Foley catheters over the past four decades (refer to Figure 2). The balloon catheter exhibits versatile applicability, serving in the preoperative, intraoperative, and postoperative phases, as our observations confirm. Notably, since 2000, there has been a marked rise in Foley catheter usage, doubling the published use of pen-neck Foley catheters over the ensuing decade.

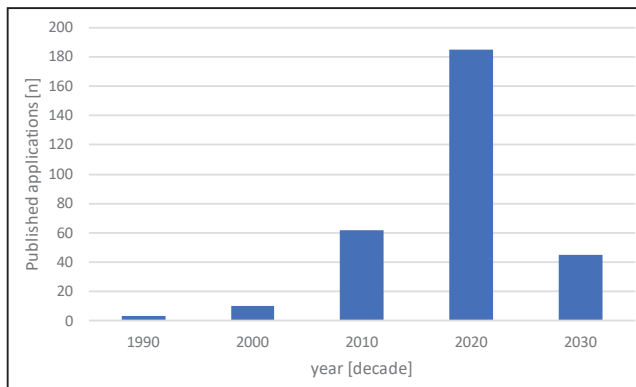


Figure 4: Application of Foley catheter in managing penetrating neck bleeding. It is pertinent to highlight that the year 2030 marks the inception of this decade, thereby signifying an ongoing investigation that remains incomplete.

In civilian contexts, the Foley catheter presents numerous advantages. It can be swiftly deployed into a wound, even by paramedics in the prehospital phase. Moreover, it can remain in place even when a neck collar is affixed. Its adaptability facilitates patient transportation, including air transit with fluctuating pressure conditions, a feat achieved by sealing it with sterile water or saline solution. Liquids hardly expand when ambient air pressure drops. In contrast, endotracheal tubes with air-filled cuffs necessitate meticulous cuff pressure control to stay within

30 mmHg during the aerial conveyance of a patient.

Most research studies and patient cases originate from the Republic of South Africa (RSA, detailed in Table 2).

Countries	FC use [n]
RSA	184
US Mil AFG	42
US Mil Irak	18
USA	15
India	11
Iraq	3
Brasil	1
Total	274

Table 1. Countries of published Foley catheter use in penetrating neck injuries and reported application numbers

Navsaria, Thoma, and Nicol studied the use of the Foley catheter in managing penetrating neck injuries within the Republic of South Africa (RSA) context. [19] Their pioneering work involved the first substantial publication of such cases. Within the scope of their study, 220 patients with penetrating neck injuries were admitted to Groote Schuur Hospital in Cape Town between 2004 and 2005. Among these patients, a subset of n=18 received balloon tamponade (8.2%). Four patients exhibited angiogram lesions among this subset, necessitating radiological intervention or surgical procedures. For the remaining n=14 patients, the Foley catheter was deflated and removed in theater settings 2-3 days post-insertion. Only one instance of rebleeding occurred, which required immediate surgical intervention. Following 24 hours of monitoring, patients were discharged from the hospital. Consequently, based on their findings, the utilization of a Foley catheter to manage a previously hemorrhaging penetrating neck wound for 48-72 hours was deemed a secure method to prevent rebleeding and avert unnecessary surgical explorations.

Study	Year	Country	Pen Injuries	FCT [n]	bleeding control[n]	removal time [hrs]	Bleeding on removal	obs [hrs]	bleeding later
Feliciano	2021	USA	1	1	1	48-72	none	48	n.s.
Kong	2021	RSA	1581	44	35	24	1	n.s.	n.s.
Scriba	2020	RSA	628	95	92	48-72	2	n.s.	n.s.
Jose	2019	India	26	11	10	72	3	n.s.	n.s.
Madsen	2018	RSA	817	11	8	8-12	5	n.s.	n.s.
Teixeira	2016	Brasil	161	1	1	OR	no postop foley	no postop foley	no postop foley
Weppner	2013	US Mil AF	77	42*	39*	OR	no postop foley	no postop foley	no postop foley
Shuker	2012	US Mil Ira	12	18	n.s.	OR	no postop foley	no postop foley	no postop foley
Van Waes	2012	RSA	78	7	6	48	2	n.s.	n.s.
Ball	2011	USA	44	13	12	6-78	n.s.	n.s.	n.s.
Navsaria	2006	RSA	220	18	17	48-96	1	24	n.s.
Sing	1998	USA	1	1*	1*	Embolisation; 4	none	4	none
Bendahan	1994	RSA	1	1	1	72	none	n.s.	none
Gilroy	1992	RSA	56	8	4	n.s.	n.s.	n.s.	n.s.
Shuker	1989	Iraq	3	3	2	192; 240; n.s.	n.s.	n.s.	n.s.
Total			3.706	274	229	range 6-240 hrs median 48-72	14	range 24-48 hrs median 24	

Table 2. Collected studies on Foley catheter application in penetrating neck injuries and their success rate in bridging and definite SNOM therapy. *neck and maxillofacial

The inquiry regarding the permissible duration for the Foley catheter to remain in place before removal prompts consideration. Table 1 presents an overview of 15 published studies, encompassing n=274 instances of initial Foley catheter application from the inception of electronic records up to the present time.

The application of a Foley catheter in managing bleeding neck wounds has gained traction in both military and prehospital settings. [20-22] In military missions, medical personnel often confront the challenges of being distant from the wounded, complicating extrication from perilous situations without endangering fellow comrades. Moreover, rescue and transportation times are considerably prolonged compared to peacetime scenarios due to mined or destroyed roads and armored vehicles needing to take secured slower routes. This temporal gap between injury and reaching a higher level of care is critical, particularly for bleeding patients, as hemorrhage accounts for a significant portion of preventable battlefield deaths. [22]

Immediate bleeding control in regions unsuitable for tourniquet application or manual compression is paramount, especially for Special Forces operating in remote areas.[23] Utilizing Foley catheters presents an intriguing opportunity for swift application—a lightweight, easily transportable tool that any paramedic in the forces can promptly apply. Weppner and Shuker's reports from recent battlefields in Afghanistan and Iraq support this approach. [20, 24]

The question arises: Can the Foley catheter be employed as a standalone therapy without further radiological or surgical intervention? Analyzing the 2006 study by Navsaria, Thoma, and Nicol from Cape Town, it was observed that among 18 patients, three with significant lesions in angiograms underwent radiological intervention or surgery, while the majority (13/18; 72%) had the Foley catheter deflated in the operating room (OR) under surgical supervision. [19]

The catheter was entirely removed five minutes after deflation. Only one case of rebleeding occurred, which was resolved with subsequent surgery. However, the optimal timing for safe Foley catheter removal after penetrating neck trauma remains undetermined, as the authors did not specify whether deflation occurred on day two or day three post-insertion.

The initial bleeding control success rate was 229 out of 274 cases (84%). The rebleeding rate after Foley catheter removal at a median of 48-72 hours was 14 out of 229 cases (6%). Unfortunately, there is limited data regarding extended catheter use, long-term bleeding rates, and associated complications.

Anesthesiologists typically leave an endotracheal tube in the trachea for 3-5 days without moving it, monitoring cuff pressure at 30mm Hg or below to prevent mucosal damage. While tracheal tissue is prone to ulceration and necrosis under prolonged pressure, neck tissue, primarily comprising connective and muscle tissue, is less sensitive.

Therefore, muscle necrosis, though a possible long-term consequence, is improbable in a reasonably inflated balloon vicinity. Hence, considering catheter occlusion in neck tissues for 3-5 days might be feasible.

Foley catheters are made out of rubber or silicone. Silicone has replaced rubber throughout the developed world for urinary catheters as silicone induces less inflammation to the urethral wall, thus leading to lesser scarring and stenosis. However, the rubbery Foleys are more elastic when pulled into soft tissues and generate more friction. These attributes make rubbery catheters more suitable for balloon tamponade and bleeding control, but the effect of the Foley model and material on balloon tamponade has yet to be studied.

Further research is warranted to ascertain the feasibility of prolonged transport and whether extending catheter placement might reduce rebleeding rates observed in the Cape Town study. If a longer Foley catheter offers more advantages and if angiographic studies can be safely conducted with the catheter in place, it could be considered a new "SNOM" (Selective Non-Operative Management.) tool for definitively managing penetrating neck injuries.[25, 26] Furthermore, more detailed studies are needed to standardize the technique for implementing and using FCs.

Conclusion

In conclusion, the Foley catheter proves to be a suitable tool for managing penetrating neck hemorrhages resulting from gunshot or stab wounds. Its primary success rate in prehospital and emergency settings surpasses pressure or chitosan techniques. The Foley catheter can perform post-primary bleeding control, subsequent examinations, and interventions. Determining the optimal time for removal, potentially around 2-3 days or even beyond, is essential. The incidence of late rebleeding is minimal, with less than one percent. Defining the criteria for qualifying a Foley catheter to remain in place as the definitive SNOM therapy for hemorrhagic penetrating neck injuries necessitates further investigation.

Ethics: This review does not contain any personal data or interventions that could potentially cause harm to human participants. Nevertheless, according to the Declaration of Helsinki, ethical standards were applied in full.[1]

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