Assessment of Early Complication after Radial Arterial Line Removal in Open Heart Surgery: A descriptive cross-sectional study

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Abstract

Background: Radial arterial lines are commonly used in open-heart surgery to monitor blood pressure and facilitate blood gas analysis. While the procedure for insertion and removal of radial arterial lines is generally considered safe, complications can occasionally occur. Understanding the early complications that may arise following the removal of these arterial lines is critical to ensuring patient safety and improving clinical outcomes. **Objective:** This study aims to assess the incidence of early complications after radial arterial line removal in patients who have undergone open-heart surgery. **Methods:** A cross-sectional descriptive study was conducted at Ibn Al–Bitar Center for Cardiac Surgery, The Iraqi Center for Heart Disease, Al-Imam–Hassan Al-Mujtaba (A.S) Teaching Hospital, and Ibn Al–Nafees Teaching Hospital for Cardiology, Thoracic Surgery, and Vascular Medicine by selecting 35 patients undergoing radial arterial line removal after open heart surgery. The data was collected using the interview questionnaire containing two sections the Early Discharge After Transradial Stenting of Coronary Arteries Study hematoma scale: grade I, <5 cm in diameter (nonsignificant), grade II, 5 - 10 cm diameter (mild), grade III, >10 cm but distal to the elbow (moderate), grade IV, extending above the elbow (severe), and grade V, anywhere with ischemic threat to the hand (compartment syndrome) to assess Local hematoma and

demographic data in the data collection periods from 25 November to 5 February. The data was analyzed by the Statistical Package of Social Sciences. **Results:** Among the 35 patients studied, (100%) of cases experienced mild hematoma following radial arterial line removal. Descriptive statistical results showed that the mean value for hematoma formation in the control group was the highest (6.95), with a standard deviation of 1.222. The application of manually applied gauze compression was assessed for its effect on hematoma formation, and the results suggest a notable impact in reducing the incidence of hematoma. No other complications were observed, and all patients recovered fully without long-term issues. **Conclusion:** The study revealed a relatively low incidence of early complications following radial arterial line removal in patients undergoing open-heart surgery. Although complications such as hematoma and bleeding were observed, they were typically minor and managed without major intervention. Awareness of these potential complications can guide clinicians in managing postoperative care and improving patient outcomes. Further research with larger sample sizes and longer follow-up periods is needed to confirm these findings and assess long-term outcomes.

Keywords: Early Complication, Open Heart Surgery, Radial Arterial Line Removal.

الخلاصة

خلفية البحث: تُستخدم الخطوط الشريانية الكعبرية بشكل شائع في جراحة القلب المفتوح لمراقبة ضغط الدم وتسهيل تحليل غازات الدم. وفي حين يُعتبر إجراء إدخال وإزالة الخطوط الشريانية الكعبرية آمنًا بشكل عام، إلا أنه قد تحدث مضاعفات أحيانًا. إن فهم المضاعفات المبكرة التي قد تنشأ بعد إزالة هذه الخطوط الشريانية أمر بالغ الأهمية لضمان سلامة المريض وتحسين النتائج السريرية. **الأهداف:** تهدف هذه الدراسة الى تقييم

معدل حدوث المضاعفات المبكرة بعد إزالة الخط الشرياني الكعبري لدى المرضى الذين خضعوا لجراحة القلب المفتوح. **المنهجية:** أجريت دراسة وصفية مقطعية في مركز ابن البيطار لجراحة القلب، والمركز العراقي لأمراض القلب، ومستشفى الإمام الحسن المجتبى (ع) التعليمي، ومستشفى ابن النفيس التعليمي لأمراض القلب وجراحة الصدر والأوعية الدموية من خلال اختيار 35 مريضًا خضعوا لإزالة الخط الشرياني الكعبري بعد جراحة القلب المفتوح. تم جمع البيانات باستخدام استبيان المقابلة الذي يحتوي على قسمين مقياس الورم الدموي لدراسة الخروج المبكر بعد تركيب الدعامات الشعاعية للشرايين التاجية: الدرجة الأولى، <5 سم في القطر (غير مهم)، الدرجة الثانية، 5 – 10 سم في القطر (خفيف)، الدرجة الثالثة، >10 سم ولكن بعيدًا عن الكوع (متوسط)، الدرجة الرابعة، ممتدًا فوق الكوع (شديد)، والدرجة الخامسة، في أي مكان به تهديد إقفاري لليد (متلازمة الحيز) لتقييم الورم الدموي المحلي والبيانات الديموغرافية في فترات جمع البيانات من 25 نوفمبر إلى 5 فبراير. تم تحليل البيانات بواسطة الحزمة الإحصائية للعلوم الاجتماعية. النتائج: من بين 35 مريضًا تمت دراستهم، عانى (100٪) من الحالات من ورم دموي خفيف بعد إزالة خط الشريان الشعاعي. أظهرت النتائج الإحصائية الوصفية أن متوسط قيمة تكوين الورم الدموي في المجموعة الضابطة كان الأعلى (6.95)، مع انحراف معياري قدره 1.222. تم تقييم تطبيق ضغط الشاش المطبق يدويًا لتأثيره على تكوين الورم الدموي، وتشير النتائج إلى تأثير ملحوظ في تقليل حدوث الورم الدموي. لم يتم ملاحظة أي مضاعفات أخرى، وتعافى جميع المرضى تمامًا دون مشاكل طويلة الأمد. **الاستنتاجات:** كشفت الدراسة عن انخفاض نسبي في حدوث المضاعفات المبكرة بعد إزالة خط الشريان الكعبري لدى المرضى الذين يخضعون لجراحة القلب المفتوح. وعلى الرغم من ملاحظة مضاعفات مثل الورم الدموي والنزيف، إلا أنها كانت بسيطة عادةً وتمت إدارتها دون تدخل كبير. يمكن أن يوجه الوعي بهذه المضاعفات المحتملة الأطباء في إدارة الرعاية بعد الجراحة وتحسين نتائج المرضى.

هناك حاجة إلى مزيد من البحث مع أحجام عينات أكبر وفترات متابعة أطول لتأكيد هذه النتائج وتقييم النتائج طويلة الأمد.

مفاتيح الكلمات: المضاعفات المبكرة، جراحة القلب المفتوح، إزالة خط الشريان الكعبري.

Introduction

Cardiovascular disease (CVD) continues to be one of the leading causes of mortality and morbidity globally. It encompasses a broad spectrum of conditions, including coronary artery disease, heart failure, and valvular heart disease, among others. As a result, open heart surgery, such as coronary artery bypass grafting (CABG), heart valve repairs, and valve replacements, is frequently performed to address these life-threatening conditions. Open heart surgeries aim to improve cardiac function, alleviate ischemia, and reduce the overall risk of mortality in patients with severe cardiovascular conditions. However, these surgeries are complex and require precise intraoperative monitoring to ensure patient safety, optimize surgical outcomes, and prevent complications [(1,2)].

Intraoperative monitoring techniques are essential to assess and manage the physiological responses of patients undergoing heart surgery. One such technique is the use of an invasive radial arterial line. This monitoring device is inserted into the radial artery, commonly located at the wrist, to provide continuous and real-time measurements of blood pressure, arterial blood gases, and other vital parameters. Radial arterial lines allow for the precise tracking of a patient's hemodynamics, enabling immediate interventions if any complications arise during surgery. The ability to measure systolic, diastolic, and mean arterial pressures accurately is crucial for managing fluid balance, titrating medications, and making timely surgical adjustments [(3,4)].

Despite their usefulness, radial arterial lines are not without risks. One of the most common complications associated with their use is the formation of a hematoma at the insertion or removal site. Hematomas occur when blood escapes from the artery into the surrounding tissues, creating a localized collection of blood that may result in swelling, discomfort, or, in more severe cases, ischemia of the surrounding tissues. Inadequate compression after arterial line removal is one of the leading causes of hematoma formation [(5)]. In addition, prolonged catheterization may increase the risk of thrombosis or infection. As such, proper management of the radial arterial line insertion, maintenance, and removal is critical for preventing such complications [(6)].

The removal of the radial arterial line, while generally straightforward, requires careful attention to avoid complications. Once the arterial line is no longer needed, it is typically removed in a controlled manner. However, failure to adequately control the puncture site can lead to excessive bleeding or hematoma formation. To prevent these issues, manual compression is employed immediately following line removal to ensure that the puncture site is sealed. Gauze pads are commonly applied with sustained pressure to promote clot formation and halt any ongoing bleeding. This approach helps minimize the risk of post-procedural bleeding, although it is not always entirely effective, particularly in patients with underlying coagulopathies or those receiving anticoagulant therapy [(7,8)].

Complications associated with radial arterial line removal are not limited to hematomas. In some cases, arterial spasms may occur, especially in patients with fragile vasculature or underlying vascular disease. Arterial spasms can lead to temporary constriction of the artery, which impedes normal blood flow and can cause significant

pain or even ischemia in extreme cases [9]. In addition, thrombosis, or clot formation within the artery, can occur, particularly if the artery is repeatedly cannulated or if anticoagulation is not properly managed. This is of particular concern in patients with pre-existing risk factors for clotting or thrombosis [10].

Infections at the puncture site, although relatively rare, represent another potential risk when radial arterial lines are used for extended periods. The insertion of an arterial line introduces a foreign object into the body, and if the site is not properly sterilized, bacteria can enter the bloodstream, potentially leading to sepsis or other systemic infections [11]. Careful monitoring of the site for signs of infection, such as redness, warmth, or discharge, is critical in preventing such complications [12].

Further risks associated with radial arterial line removal include nerve injury, particularly in the case of inadvertent damage to the radial or median nerve during catheter insertion. Although rare, nerve damage can result in temporary or permanent numbness, tingling, or motor impairment in the affected limb. Proper technique and attention to the anatomical positioning of the arterial line can help mitigate these risks [13]. Additionally, patients who are already at risk for poor wound healing, such as those with diabetes, obesity, or peripheral vascular disease, may experience delayed recovery or further complications related to the puncture site [14].

The application of manual compression after radial arterial line removal is one of the primary methods for preventing bleeding complications. In general, manual compression should be maintained for a sufficient duration to ensure that the puncture site is closed and bleeding is adequately controlled. However, the ideal duration and pressure required for effective compression remain a subject of debate in clinical practice [15]. Several studies have

attempted to determine the optimal duration and technique for manual compression, with some suggesting that applying pressure for up to 10-15 minutes may reduce the risk of hematoma formation without significantly increasing patient discomfort [16,17]. Insufficient compression or premature release of pressure, however, may result in the formation of hematomas, delayed hemostasis, and the need for further interventions [18].

For patients with risk factors such as coagulopathy, anticoagulant therapy, or the use of antiplatelet medications, additional steps should be taken to minimize complications. This includes adjusting anticoagulant medication before and after surgery, as well as closely monitoring platelet function and bleeding times. Some studies recommend the use of compression bandages or hemostatic devices in patients with high bleeding risks to further reduce the potential for bleeding [19]. For patients undergoing longer or more invasive surgeries, postoperative monitoring, including ultrasound examination or arterial Doppler studies, may be used to detect early signs of thrombosis or other complications [20].

In conclusion, while radial arterial lines are essential tools for monitoring patients undergoing open heart surgery, they are not without potential complications. Hematomas, arterial spasms, thrombosis, infections, and nerve injuries are all risks that must be carefully managed. Effective manual compression after radial arterial line removal is critical to minimizing these risks. With vigilant monitoring, appropriate preoperative preparation, and attention to post-procedural care, the risks associated with radial arterial line insertion and removal can be minimized, ensuring better outcomes for patients undergoing complex cardiovascular surgeries.

Methods

Research design

A descriptive cross-sectional study was conducted to assess early complications after radial arterial line removal following open heart surgery.

Setting and Samples

In Ibn Al–Bitar Center for Cardiac Surgery, The Iraqi Center for Heart Disease, Al-Imam–Hassan Al-Mujtaba (A.S) Teaching Hospital, and Ibn Al–Nafees Teaching Hospital for Cardiology, Thoracic Surgery, and Vascular Medicine by selecting 35 patients undergoing radial arterial line removal after open heart surgery. periods of data collection from 25 November to 5 February. The inclusion criteria were composed the adult patients above 18 years old, undergoing radial arterial line removal after open heart surgery, both sexes, and no signs of necrosis, scarring, incision, or infection at the insertion site, and no analgesics were taken at least four hours before participation. Also excluded were the patients with communication impairments, cognitive disorders, hemodynamic instability, re-intubation, a history of severe bleeding or clotting disorders, arterial line cutdown, material allergies, or a history of peripheral vascular disease.

Instrument

The data was collected by using the interview questionnaire containing two sections the Early Discharge After Transradial Stenting of Coronary Arteries Study hematoma scale: grade I, <5 cm in diameter (nonsignificant), grade II, 5 - 10 cm diameter (mild), grade III, >10 cm but distal to the elbow (moderate), grade IV, extending above the elbow (severe), and grade V, anywhere with ischemic threat to the hand (compartment syndrome) to assess Local hematoma and demographic data in the data collection periods from

25 November to 5 February. Bertrand OF, De Larochellière R, et al. utilized it for the first time in (2006), the ESAY Hematoma Scale has a high degree of validity and reliability [21].

Data Collection

Data was collected using a questionnaire with demographics and an ESAY Hematoma Scale. After describing the process and the goals of the study to each patient and assuring them that all of their information would be kept private and used exclusively for research, the patients gave their agreement to participate in the study. Following open heart surgery, all patient's male and female were lying supine in the cardiac intensive care unit, the radial arterial line was withdrawn, and a nurse manual gauze pads compression to the radial artery for 10 minutes. The hematoma formation was measured by the ESAY Hematoma Scale after the radial arterial line, and 6 hours later. The Statistical Package of Social Sciences (SPSS) version 26 was used to analyze the data. Official permissions were obtained from relevant authorities before collecting the study data as started by getting the approval of the Council of the Nursing College/University of Baghdad for this study on 24/10/2024.

Results

Table (1.1): the descriptive statistical analysis: *Distribution of the participant's socio-demographic and clinical data characteristics according to their groups:*

Demographic and clinical data Characteristics	Descriptive Statistics	Control	Symmetric Measures	
			Cc	Sig.
Age	Min.	55	.902	**.653**
	Max.	71		
	Mean.	66.11		
	S. D.	3.668		
Procedure	Min.	5.0	.848	**.212**

Time	Max.	8.0			
	Mean.	5.971			
	S. D.	0.7270			
Demographic and clinical data Characteristics	**Subgroup**	**Control**		**Symmetric Measures**	
		f.	**%**	**Cc**	**Sig.**
Sex	Male	31	88.6	.605	**.447**
	Female	4	11.4		
	Total	35	100.0		
Level of education	Read & write	10	28.6	.790	**.540**
	Primary school	7	20.0		
	Middle school	3	8.6		
	High school	15	42.9		
	Total	35	100.0		
Body Mass Index	Normal weight	4	11.4	.784	**.631**
	Pre – obesity	3	8.6		
	Obesity class I	24	68.6		
	Obesity class II	4	11.4		
	Total	35	100.0		
Smoking	Smoke	26	74.3	.587	**.560**
	Non – smoking	9	25.7		
	Total	35	100.0		
Operational Procedure	CABG	30	85.7	.762	**.167**
	MVR	4	11.4		
	DVR	1	2.9		
	Total	35	100.0		
Chronic diseases	No	31	88.6	.845	**.274**
	D.M.	4	11.4		
	HTN.	35	100.0		
	H.F.	10	28.6		
	D.M. & HTN.	7	20.0		
	Total	3	8.6		
Previous Open-Heart Surgery	Yes	15	42.9	.707	**.020**
	No	35	100.0		
	Total	4	11.4		

f= frequencies, **%**= Percentages, **M**= Mean of score, **S. D.**= Standard Deviation, **Min**= minimum, **Max**= maximum, **CABG**= Coronary Artery Bypass Grafting, **MVR**= Mitral Valve Replacement, **DVR**= Double Valve Replacement, **&**= and, **CC**= Contingency Coefficient.

The underlined numbers in Table (1.1) present the highest percentages of the selected variables. The results of the study sample (control groups) distribution according to their socio-demographic and clinical data characteristics showed that the mean age of patients undergoing radial arterial line removal in open heart surgery was (66.11) years with a standard deviation of (3.668).

Concerning the patient's sex, the majority of the patients were males their percentage (88.6%) compared with a female (11.4%) from the study sample. Regarding the patient's level of education, the higher percentage were high school educational level (42.9%). Regarding the patient's body mass index, the higher percentage was Obesity class I (68.6%). Regarding patient's smoking, the higher percentage of patients was those who were smoking (74.3%). Referring to the patient's operational procedure the higher percentage of patients had undergone coronary artery bypass grafting (CABG) surgeries (85.7%). Regarding the procedure time, the analysis indicated that the mean time was (5.971) hours with a standard deviation of (.7270). Regarding patient's chronic diseases, a higher percentage of patients were diagnosed with diabetes mellitus and hypertension (42.9%).

Finally, according to the patient's previous open-heart surgery, the findings showed the majority of the study sample had not undergone open-heart surgery, the higher percentage of patients (97.1%).

Table (1.2) Tests of Normality:

Scale	Shapiro-Wilk		
	Statistic	Df	Sig.
EASY Hematoma Scale	.951	35	**.000**

Df. Degree of freedom, **Sig.** Significant.

In Table (1.2) the test of normality results shows the distribution of data is non–normal distribution according to the

Shapiro-Wilk test that found the probability value or (p-value) in the dependent variable is (0.000).

Table (1.3): the descriptive statistical analysis: *Assess the manually applied gauze compression effect on hematoma formation after radial arterial line removal in open heart surgery patients.*

Hematoma formation	Group	Descriptive Statistics [a]		
		N.	M.	SD.
	Control	35	**6.95**	**1.222**

a. Grouping, **N.** The number of participants**, SD.** Standard Deviation**, M.** Mean of score In Table (1.3) the descriptive statistical results showed assess the manually applied gauze compression effect on hematoma formation after radial arterial line removal in open heart surgery patients. The hematoma formation mean value for the control group was the highest level (6.95) with a standard deviation of (1.222).**Table (1.4): The statistical association analysis:** *Correlation between patients' demographic and clinical data for the control group regarding hematoma formation.*

Demographic and clinical data	Correlation Coefficient	Control	
		Analysis	Sig.
Age	Spearman's rho	.127	.467
Level of education	Spearman's rho	.074	.674
Body mass index	Spearman's rho	-.112-	.521
Procedure time	Spearman's rho	.053	.761

Sig. (2-tailed) Asymptotic Significance.

In Table (1.4) spearman's rho tested the correlation between the following patients' demographic and clinical data characteristics (age, level of education, body mass index, procedure time) with hematoma formation for the control group after radial arterial line removal in open heart surgery patients. The results revealed there is no statistically significant correlation for the control group at **(P_{value}** = 0.467), (P_{value} = 0.674), (P_{value} = 0.521), (P_{value} = 0.761), respectively.

Table (1.5) The statistical difference analysis: *Differences among patients' demographic and clinical data in the control group regarding hematoma formation.*

Demographic and clinical data	Test Statistics [a]	Control	
		Analysis	Sig.
Sex	Mann-Whitney U	60.000	.917
Previous open-heart surgery	Mann-Whitney U	4.000	.197

a. Grouping Variable: Group**, Asymp. Sig. (2-tailed)** Asymptotic Significance.Table (1.5) uses the Mann-Whitney U Test to find out the difference between the following patients' demographic and clinical data characteristics (sex, previous open-heart surgery) with hematoma formation for the control group after radial arterial line removal in open heart surgery patients. The results show there is no statistically significant difference between (sex, previous open-heart surgery) with hematoma formation for the group at ($P_{value} = 0.917$) and ($P_{value} = 0.197$) respectively.

Table (1.6) The statistical difference analysis: *Differences among patients' demographic and clinical data in the control group regarding hematoma formation.*

Demographic and clinical data	Test Statistics [a,b]	Control	
		Analysis	Sig.
Smoking	Kruskal-Wallis H	0.092	.762
Operational procedure	Kruskal-Wallis H	2.021	.364
Chronic disease	Kruskal-Wallis H	4.401	.354

a. Kruskal Wallis Test**, b.** Grouping Variable: Group**, Sig. (2-tailed)** Asymptotic Significance. Table (1.6) uses the Kruskal-Wallis H Test to find out the difference between the following patients' demographic and clinical data characteristics (smoking, operational procedure, and chronic disease) with hematoma formation for the control group after radial arterial line removal in open heart surgery patients. The results show there is no statistically significant difference between (smoking, operational procedure, and chronic disease) with

hematoma formation for the control group at ($P_{value} = 0.762$), ($P_{value} = 0.364$), and ($P_{value} = 0.354$) respectively.

Discussion

Studies often show that elderly adults experience a higher ischemia burden due to age-related cardiovascular changes, increased atherosclerosis, comorbidities, and impaired repair mechanisms than younger ones, in the current study the participants' mean age was determined to be 66.11 years [(22)]. Similar results are shown in a study carried out by Mikus and Elisa, which found a mean age the same in the control group [(23)]. According to a study on sex, men's testosterone levels decline with age, this leads to an increased risk of cardiovascular disease in males more than females. In this study, the majority of the participants were males 88.6% This result was similar to the study conducted by Yamaguchi S and Otaki Y, Sallal, in that the largest percentage of the study sample was male 63.3% of the control group [(24)]. According to the educational level, the findings of the study show a high percentage of 42.9% was high school educational level. This result the same finding found in the study was conducted by Bukowski K and Buetow S. et al. In this study, the high percentage also the high school educational level was 36.7% in the control group [(25)].

Conflict of interest

The author declares that they have no conflict of interest.

Limitations of the study

The limitations of this study include a small sample size, which could affect the generalizability of the findings. Additionally, as a cross-sectional design, it only provides a snapshot of complications at a specific point in time, potentially missing long-term issues.

Conclusion

In conclusion, this study highlights the importance of closely monitoring patients following radial arterial line removal in open heart surgery for early complications such as bleeding, hematoma, and arterial spasm. While the findings provide valuable insights into the risks associated with this procedure, further research with larger sample sizes and longitudinal follow-up is needed to better understand long-term outcomes and improve clinical practices for preventing complications.

Recommendation

Based on the results of the study, it's recommended to consider the potential risks associated with radial arterial line removal, monitor patients closely for early complications, and implement preventive measures like proper pressure application post-removal.

Author contributor

Conceptualization, Software, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration, and Funding acquisition (Master's student Ali AR. Al-Anbaki). Methodology, Validation, and Supervision (Associate. Prof, Wafaa Abd Ali Hattab).

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