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Research Article

DO TEACHING HOSPITALS HAVE COMPARABLE OUTCOMES TO NON-TEACHING HOSPITALS FOR PERCUTANEOUS CORONARY INTERVENTIONS?

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ABSTRACT

Objectives: Teaching hospitals may have comparable surgical outcomes as compare to non-teaching hospitals from major surgical conditions. However, limited data are available regarding percutaneous coronary interventions performed in teaching hospitals involving trainées.

Methods: In this observational study, 103 patients who had percutaneous coronary intervention (PCI) in a hospital attached to a medical college were retrospectively evaluated. The indications for PCI were ST-elevation myocardial infarction (STEMI), improvement in quality of life in patients with atypical chest pain, angina (stable and unstable, a positive stress test, or non-STEMI, and patients without any documented angina, chest pain, or positive stress test. Teaching hospital status was as defined by the National Medical Commission-based number of teaching faculty/trainees to-bed ratio. Trainee participation in at least 50% PCI procedures in the teaching hospital was a pre-requisite for inclusion in the study.

Results: The mean age of participants was 60.4±9.8 years; there was a male preponderance (84.4%). Prior PCI was done in 11.3% patients and 7.5% had history of stroke previously. About 20.6% were diabetics, 33.9% had dyslipidemia, and 50.9% had systemic hypertension, respectively. Left anterior descending with the left coronary circumflex artery was the most affected vessels in both sexes combined and 84.4% patients had double-vessel disease. Thirty-one (31.9%) underwent PCI by femoral route and 72 (68%) by radial route, respectively. PCI was successful in 74 (71.8%) and 10 (9.7%) had vascular complication. The mortality rate was 6 (5.8%). Twenty-five (24.3%) patients had reinfarction.

Conclusion: Although vascular complications may occur at the hands of trainees, the overall mortality rates are low for PCI in teaching hospitals.

Keywords: Percutaneous coronary intervention, Myocardial infarction, Teaching hospital.

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INTRODUCTION

Teaching hospitals, or academic training centers which are affiliated with medical colleges train the upcoming physicians. Teaching hospitals are known for their ability to deliver advanced clinical and surgical care; however, there is limited availability of data regarding costs and outcomes. It is also not known which patient groups the actual beneficiaries receiving tertiary care at these hospitals [1,2].

A study conducted by Holena *et al*. found that teaching hospitals had better surgical outcomes for planned surgical procedures, but the mortality risk was higher for surgeries conducted in emergencies [3]. However, it is not known whether these observations also hold good for invasive cardiac procedures or vice versa.

Coronary artery bypass grafting (CABG) is the most performed cardiac procedure worldwide in patients with coronary artery disease (CAD) [4]. Percutaneous coronary intervention (PCI) is a non-surgical procedure in which a catheter (a thin flexible tube) is used to place a small a stent to open blood vessels in the heart that have been blocked by atherosclerosis; it is currently the standard treatment modality for patients with myocardial infarction (MI) (ST-elevation) [5,6].

Studies conducted in the Indian subcontinent indicate that CAD is on the rise; the prevalence is significantly higher than that in developed countries. In Indian patients, there are several peculiar features of CAD; it tends to occur at a younger age, the incidence of double-vessel disease (DVD) and triple-vessel disease is significantly higher, involvement is diffuse, there is distal disease, and patients may have a significant left ventricular (LV) dysfunction at presentation. Studies have reported significantly improved outcomes with reduced mortality when PCI has been used in combination with other treatment modalities [7]. However, the PCI procedure per se may be associated with vascular complications such as bleeding and other complications [8,9].

Aa far as the approach for intervention is concerned, the transfemoral approach has been the preferred access site for PCI. However, reduced hemorrhage at the access site has been reported with the trans-radial approach [10,11]. Therefore, there has been a drift toward trans-radial approach for performing PCI in some countries including the United States [12,13].

In India, PCI is a routine procedure in specialized tertiary care hospitals. However, there are limited data regarding PCI done in medical schools involving trainee participation. A search of major databases including PubMed did not reveal any study reporting outcomes of PCI in these institutes.

The general belief is that there may be a potentially higher risk of complications in trainee hospitals; this is to accommodate for the learning curve of trainees and less experienced surgeons. Having said this, teaching hospitals may have a more established network with government subsidies offering cost-effective treatment to patients. This may somewhat outweigh the risk of the involvement of less experienced surgeons and trainee participation in the operative procedure. The present study aimed to compare patient characteristics and outcomes of PCI at a tertiary care teaching hospital in the Indian subcontinent.

METHODS

Study design

A single-center observational study was conducted at a tertiary care teaching hospital in the subcontinent from June 2022 to June 2023. The trial was approved by the Institutional Ethics Committee. A written informed consent was obtained from all participating patients based on the tenets of the Declaration of Helsinki.

Study participants

Inclusion criteria

In this study, 103 patients who had PCI from January 2022 to January 2023 in a hospital attached to a medical college were included in the study.

Indications for PCI

PCI was performed for ST-elevation MI [STEMI], to improve in quality of life in patients with atypical chest pain, angina (stable and unstable angina), a positive stress test, or non-STEMI, and patients without any documented angina, chest pain, or positive stress test. Coronary intervention was performed by either the trans-radial approach or trans femoral approach, respectively.

Exclusion criteria

The patients with renal dysfunction (serum creatinine >1.5 mg/dL), LV ejection fraction <30%, or systolic heart failure (decompensated), diabetes mellitus (uncontrolled), presence of comorbid disease needing hospitalization, and valvular heart disease were excluded from the study.

Patients with previous PCI within 1 year were also excluded from the study. Other criteria for exclusion were previous CABG, stroke with neurological deficit or any cerebrovascular accident (past 6 months), severe hepatic dysfunction (aspartate aminotransferase and alanine aminotransferase more than 3 times upper normal reference values) and gastrointestinal or genitourinary bleeding within 3 months or major surgery within 2 months.

All the patients had investigations such as lipid profile, 12 lead electrocardiography, transthoracic two-dimensional echocardiography, and angiography of coronary arteries, before intervention.

CAD

Patients were labeled as having CAD if major coronary arteries had more than 70% reduction in lumen diameter; these included left anterior descending (LAD), left circumflex (LCX), or right coronary artery (RCA) and their branches. Patients with the left main coronary artery lumen reduction >50% were also considered as having CAD.

Definitions

Multivessel disease

Greater than 70% lumen reduction in two or more coronary arteries or >70% lumen reduction in one coronary artery and >50% lumen reduction in a second coronary artery or >50% limen reduction in two or more coronary arteries was labeled as having multivessel coronary disease. A successful primary PCI was one with restoration of flow Grade 3 and minimum residual narrowing of <30% after the procedure.

A patient was said to be in cardiogenic shock when systolic blood pressure was <90 mmHg for more than 30 min (without drug or mechanical support) and was unresponsive to standalone fluid replacement. In addition, there were signs of end-organ hypoperfusion such as cold extremities, altered mental status, or anuria.

Definition of teaching hospital in the Indian subcontinent

Teaching status as defined by the National Medical Commission (NMC) was based on the presence of an NMC-accredited post-graduate training program, the number of teaching faculty/trainees to-bed ratio, and recognition to the commission of the medical college-attached teaching hospital. In our teaching hospital, trainees undergoing DM in cardiology are routinely posted in the cardiac catheterization laboratory and required to assist in at least 50% of PCI procedures performed during their posting. A minimum of "scrubbing-in" during the intervention was considered as satisfactory trainee participation in the intervention.

Outcome measures

The following variables were considered during PCI; mortality in the hospital, emergency CABG (emergency/elective), nephropathy due to contrast or that requiring dialysis, stroke, or transient ischemic attack (TIA), MI in the hospital, and vascular complications (if any). Gastrointestinal bleeding was also noted.

Increase in cardiac biomarkers (no sooner than 6 h post-PCI) >3 times the upper reference limit after the procedure was MI during the procedure. Emergency CABG was defined as the direct shifting of the patient transport from the cardiac catheterization laboratory to the operating room. All CABG was defined as bypass surgery at any point following PCI and before discharge from the hospital. Major adverse cardiac events were a combination of death, stroke/TIA, MI, CABG, and repeat PCI of the same lesion.

Death included mortality from both cardiac and non-cardiac causes. Stroke was defined as a focal neurological deficit lasting longer than 24 h. Nephropathy due to contrast was defined as an increase in serum creatinine levels by >0.5 mg/dL after the procedure.

Follow-up

At discharge, patients were provided the contact number of the hospital emergency and the attending trainee for any emergency. All patients were advised to report to the cardiac outpatient department (OPD) 2 days after the procedure with KFT reports. Thereafter, the patients were followed up in OPD monthly for 6 months.

Statistics

Statistical analysis was performed using IBM statistical software, SPSS Statistics version 29 (IBM Inc.). Data were checked for normality using Shapiro–Wilk test. Outliers were identified by visual inspection of boxplots. Descriptive measures, such as mean with standard deviation (SD), were calculated for all continuous variables, whereas frequencies and percentages were calculated for all categorical variables. The independent-sample's t-test was used to determine if a difference exists between the means of two independent groups on a continuous dependent variable. Association between two categorical variables was evaluated using the Chi-square tests. $p<0.05$ was considered statistically significant.

RESULTS

Table 1 shows baseline demographics, clinical characteristics, and preprocedural patient variables including medications.

At our teaching institute, 31 (31.9%) underwent PCI by femoral route and 72 (68%) by radial route, respectively ($p=0.020$). Table 2 summarizes the type of CAD by gender. Most patients (84.4%) had DVD in our cohort.

The angiographic profile of patients is summarized in Table 3. The LAD artery along with LCX was involved in (36.8%), LAD with RCA (14.9%), LCX with RCA (14.9%), and LAD with LCX and RCA (11%) were the frequent vessels affected in males, respectively.

In females, LAD with LCX (18.7 %), LAD with RCA (12.5%), and LAD with D1 (12.5%) were the frequent vessels affected in females. LAD with LCX were the most affected vessels in both sexes combined ($p=0.001$).

In this study, 74 (71.8%) patients had successful PCI. However, 25 (24.3%) developed reinfarction during 1-year follow-up. Ten (9.7%)

Table 1: Baseline characteristics

Characteristic	Mean±SD/n (%)
*Age (years)	60.4±9.8
#Male gender	87 (84.4)
#Diabetes	22 (20.7)
#Chronic renal insufficiency	4 (3.8)
#Previous MI	10 (9.4)
#Previous PCI	12 (11.3)
Current smoker	44 (41.5)
#Hypertension	54 (50.9)
#Dyslipidemia	36 (33.9)
#Previous stroke	8 (7.5)
#Time from symptom onset to index PCI	
<6 h	72 (67.9)
6–12 h	26 (24.5)
>12 h	8 (7.54)
#Glycated hemoglobin %	6.4±1.6
*LDL (mmol/L)	3±1.4
*Peak creatinine (umol/L)	82.7±28.6
#Medications (on discharge)	
Aspirin	103 (98)
Clopidogrel	28 (26.4)
B-blocker	90 (84.9)
ACE inhibitor	98 (92.40)
Statins	103 (98)

*Expressed as Mean±SD, #Expressed as frequency and percentage, MI: Myocardial infarction, PCI: Percutaneous coronary intervention, LDL: Low-density lipoprotein, ACE: Angiotensin-converting enzyme

Table 2: Type of coronary artery disease

#Gender	Double-vessel disease	Tripple-vessel disease
Male	12 (11.6)	5 (4.8)
Female	75 (72.8)	11 (10.67)
Total	87 (84.4)	16 (15.6)

#Expressed as frequency and percentage

Table 3: Predominant coronary artery branch affected

Affected coronary branch	Males (n=87)	Females (n=16)	p-value
LAD, D1	5 (5.7)	2 (12.5)	0.056
LAD, D 2	1 (1.1)	1 (6.3=2)	0.986
LAD, LCX	32 (36.8)	3 (18.7)	0.001
LAD, LCX, LMCA	1 (1.1)	1 (6.2)	0.998
LAD, LCX, RCA	10 (11)	2 (12.5)	0.001
LAD, OM 1	6 (6.9)	1 (6.2)	0.020
LAD, RCA	13 (14.9)	2 (12.5)	0.001
LCX, OM	3 (2.9)	0	0.123
LCX, RCA	13 (14.9)	1 (6.2)	0.001
LCX, PDA	1 (0.97)	1 (6.2)	0.978
LMCA, LAD	2 (2.3)	1 (6.2)	0.856
RCA, OM	1 (1.1)	0	0.912
RCA, LCX, D1	1 (1.1)	0	0.924

LAD, D1: Left anterior descending artery, first diagonal artery, LAD, D2: Left anterior descending artery, second diagonal artery, LCX: Left coronary circumflex artery, LMCA: Left main coronary artery, RCA: Right coronary artery, OM 1: First obtuse marginal artery, PDA: Patent ductus arteriosus

had vascular complications related to the procedure. The overall mortality rate was 6 (5.8%). The outcomes of PCI are mentioned in Table 4. Primary PCI was performed in 26 (25.2%), emergency PCI in 40 (38.8%), and elective PCI in 33 (32%) patients, respectively.

The causes of sub-optimal outcomes are mentioned in Table 5. Uncontrolled diabetes and left-ventricular diastolic dysfunction were the most common causes of sub-optimal outcome.

Table 4: Outcomes of PCI

#Variable	n (%)
Primary-PCI	26 (25.2)
Emergency PCI	40 (38.8)
Elective PCI	33 (32)
Vascular complications	10 (9.7)
Re-infarct	25 (24.3)
Successful PCI	74 (71.8)
Stroke	2 (1.9)
Death	6 (5.8)
Survived	96 (93.2)

#Expressed as frequency and percentage, PCI: Percutaneous coronary intervention

Table 5: Causes of sub-optimal outcomes

#Causes for suboptimal result in multivessel PCI	n (%)
Diabetes mellitus (uncontrolled)	10 (9.7)
Diffuse disease	5 (4.8)
LAD involvement	5 (4.8)
LV systolic dysfunction	6 (5.8)
Time from onset of symptoms to presentation in hospital	3 (2.9)

#Expressed as frequency and percentage, PCI: Percutaneous coronary intervention, LAD: Left anterior descending, LV: Left ventricular

DISCUSSION

The present prospective study evaluated outcomes of PCI at a tertiary care teaching hospital in the northern part of the Indian subcontinent. The results of our study show that PCI was successful in 71.8% of patients. However, 25 (24.3%) had a reinfarction in the 1st year of follow-up. In 10 (9.7%) cases, there were vascular complications related to the procedure.

The past two decades have seen an upsurge in PCI being performed in all centers including teaching hospitals. Previously, most PCI was performed in super specialty non-teaching centers of excellence. A generalized perception exists that medical schools/colleges are there to treat rare, severe diseases, and specialize in treating only complex patients [14-16].

Published studies suggest that for common medical conditions such as chronic obstructive pulmonary disease, MI, congestive heart failure, and stroke, teaching hospitals have improved risk-adjusted mortality rates for admitted patients [17-19]. These studies suggest that a significantly higher number of invasive medical procedures are being performed for these common medical conditions in teaching hospitals [20]. However, there is a paucity in the literature of studies comparing outcomes of these procedures between teaching and non-teaching hospitals.

Several studies have reported the impact of hospital teaching status on surgical outcomes. In a sample of United states national database, Holena *et al.* conducted a study to evaluated general surgical procedures (emergency and elective). The authors found that teaching status was associated with an increased risk of mortality for emergency cases. There was a higher incidence of post-operative infections at teaching hospitals as compared to non-teaching hospitals after elective surgeries (OR=1.14; $p<0.007$) [3]. In our study, the mortality rate was 5.5% for emergency procedures. However, the study design did not permit direct comparison with mortality data of non-teaching hospitals.

Khuri *et al.* conducted a study to determine whether the investment for postgraduate teaching and training puts patients at risk for adverse outcomes and increase health care costs as compared to similar care was provided in non-teaching hospitals. An independent investigator (research fellow) determined the teaching status of the hospital using a structured questionnaire. A multiple logistic regression model was constructed to predict mortality and morbidity for each surgical specialty. A severity index was also calculated for each patient. Compared with non-teaching hospitals, the prevalence of risk factors was higher for patients in teaching hospitals. In teaching hospitals, more complex operations were performed and had longer operation time. The authors found that the mortality rates were significantly higher in teaching hospitals (after adjusting for potential confounders) [21].

Gopaldas *et al*. compared coronary artery bypass (CABG) outcomes between teaching and non-teaching hospitals based on the academic calendar cycle. In the subcontinent, postgraduate course commences in July, and the joining of fresh postgraduates (limited clinical experience) marks the new academic cycle. The primary endpoints for the study were risk-adjusted mortality (risk-adjusted), the presence of a complication, and death after a complication. The authors found that compared to non-teaching hospitals, teaching hospitals were associated with lower mortality despite higher complication rates in the start of the academic cycle due to fresh trainee participation. The reduced death rates imply that the teaching hospitals are more proficient at diagnosing and managing complications after they occur. The probable explanation for this observation could be the impact of frequent in-hospital rounds by postgraduate trainees in teaching hospitals [22].

In our study, vascular complications related to PCI procedure were observed in 5.8% of patients. Studies have reported that vascular complications following PCI increase morbidity, length of stay in the hospital, healthcare costs, rate of bleeding, the requirement for blood transfusion, and mortality [23-26]. Teaching hospitals had significantly higher rates of arteriovenous fistula, hematoma requiring transfusion, pseudoaneurysm, and thrombosis. Involvement of trainees in PCIs involving femoral arterial access during the procedure which could be the possible reason for increased vascular complications. In our study, radial route was the predominant route of access, and hence, the rate of vascular complications was relatively less. Having said this, the risk of vascular complications is significantly higher with trainee participation; however, other factors also play a likely role in influencing these differences.

It is a known fact that in most invasive procedures, complication rates are inversely proportional with surgeon experience and vice versa [27,28]. Several randomized controlled trials have demonstrated the benefit of simulation training in improving procedure handling, surgeon confidence, and decreasing complication rates [29,30]. Teaching hospitals routinely conduct simulation training programs for femoral arterial access now. Routine training on simulators before involvement in clinical procedures could positively impact rates of vascular complications at teaching institutions.

Trainee participation is involved in the majority of cardiac catheterization laboratories in teaching hospitals; it is reasonable to hypothesize that teaching hospitals may have increased rates of contrast-induced nephropathy. However, we did not observe such findings at our teaching hospital.

The findings of this study are important for several reasons. First, they provide a reasonable assurance that PCI can be safely performed at teaching hospitals with satisfactory outcomes. Second, these findings can ease patient decisions and influence referral patterns in teaching hospitals. This may pave the way for a system in which all patients have easy and cost-effective access to interventions like PCI.

Our study had several limitations. First, outcomes were not compared with non-teaching hospitals. Selection bias cannot be ruled out in a non-randomized study design. The sample size was relatively small (n=103) and cannot be considered representative of the regional population; this may have led to type 2 error and consequently overestimation.

CONCLUSION

In teaching hospitals, vascular complications may occur during PCI but are less frequent with the trans-radial approach. The overall rate of morbidity and mortality is low even with trainee participation. As CAD has reached an epidemic proportion in India in the past few years, all teaching hospital need to develop state-of-the-art cardiac catheterizations laboratories.

AUTHOR CONTRIBUTIONS

All authors have contributed toward the manuscript.

CONFLICTS OF INTEREST

Nil.

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REFERENCES

1. Ayanian JZ, Weissman JS. Teaching hospitals and quality of care: A review of the literature. Milbank Q. 2002;80:569-93.
2. Allison JJ, Kiefe CI, Weissman NW, Person SD, Rousculp M, Canto JG, *et al*. Relationship of hospital teaching status with quality of care and mortality for Medicare patients with acute MI. JAMA. 2000;284:1256-62.
3. Holena DN, Hadler R, Wirtalla C, Carr B, Morris JB, Kelz RR. Teaching status: The impact on emergency and elective surgical care in the US. Ann Surg. 2011;253:1017-23.
4. Favaloro RG. Arteriosus vein autograft replacement of severe segmental coronary artery occlusion: Operative technique. Ann Thorac Surg. 1968;5:334-9.
5. Gruntzig A. Transluminal dilatation of coronary-artery stenosis. Lancet. 1978;1:263.
6. Yang Y, Zhang Y, Ren L. Prognosis analysis of delayed call time for chest pain in patients with acute ST-segment elevation myocardial infarction undergoing direct percutaneous coronary intervention. Clin Appl Thromb Hemost. 2023;29:10760296231186811.
7. Kaul U, Bhatia V. Perspective on coronary interventions & cardiac surgeries in India. Indian J Med Res. 2010;132:543-8.
8. Kaddoura R, Mohamed Ibrahim MI, Al-Badriyeh D, Omar A, Al-Kindi F, Arabi AR. Intracoronary pharmacological therapy versus aspiration thrombectomy in STEMI (IPAT-STEMI): A systematic review and meta-analysis of randomized trials. PLoS One. 2022;17:e0263270.
9. Holroyd EW, Mustafa AH, Khoo CW, Butler R, Fraser DG, Nolan J, *et al*. Major bleeding and adverse outcome following percutaneous coronary intervention. Interv Cardiol. 2015;10:22-5.
10. Murali S, Vogrin S, Noaman S, Dinh DT, Brennan AL, Lefkovits J, *et al*. Bleeding severity in percutaneous coronary intervention (PCI) and its impact on short-term clinical outcomes. J Clin Med. 2020;9:1426.
11. Elfar S, Onsy A, Farouk MA. Clinical and radiographic predictors of successful coronary angiography through right radial artery access. Interv Cardiol. 2023;18:e21.
12. Mohammad AM, Shammo NA, Saeed SY. Rates of the trans-radial approach in elective and emergency coronary angiography in Iraq: A cross-sectional study. Cureus. 2023;15:e41193.
13. Changal K, Syed MA, Atari E, Nazir S, Saleem S, Gul S, *et al*. Transradial versus transfemoral access for cardiac catheterization: A nationwide pilot study of training preferences and expertise in The United States. BMC Cardiovasc Disord. 2021;21:250.
14. Spence J, Bell DD, Garland A. Variation in diagnostic testing in ICUs: A comparison of teaching and nonteaching hospitals in a regional system. Crit Care Med. 2014;42:9-16.
15. Papanikolaou PN, Christidi GD, Ioannidis JP. Patient outcomes with teaching versus nonteaching healthcare: A systematic review. PLoS Med. 2006;3:e341.
16. Dimick JB, Cowan JA Jr., Colletti LM, Upchurch GR Jr. Hospital teaching status and outcomes of complex surgical procedures in the United States. Arch Surg. 2004;139:137-41.
17. Savoj J, Mikhail C, Ayutyanont N, Gulati R, Popa R, Popa A. The effect of starting a new residency program on the quality-of-care measures at a community hospital: A 2-year follow-up. HCA Healthc J Med. 2021;2:223-8.
18. Rosenthal GE, Harper DL, Quinn LM, Cooper GS. Severity-adjusted mortality and length of stay in teaching and nonteaching hospitals. Results of a regional study. JAMA. 1997;278:485-90.
19. Rubiano S, Gil F, Celis-Rodriguez E, Oliveros H, Carrasquilla G.

Critical care in Colombia: Differences between teaching and nonteaching intensive care units. A prospective cohort observational study. J Crit Care. 2012;27:104.e9-17.

20. Zimmerman JE, Shortell SM, Knaus WA, Rousseau DM, Wagner DP, Gillies RR, *et al*. Value and cost of teaching hospitals: A prospective, multicenter, inception cohort study. Crit Care Med. 1993;21:1432-42.
21. Khuri SF, Najjar SF, Daley J, Krasnicka B, Hossain M, Henderson WG, *et al*. Comparison of surgical outcomes between teaching and nonteaching hospitals in the Department of Veterans Affairs. Ann Surg. 2001;234:370-82; discussion 382-3.
22. Gopaldas RR, Overbey DM, Dao TK, Markley JG. The impact of academic calendar cycle on coronary artery bypass outcomes: A comparison of teaching and non-teaching hospitals. J Cardiothorac Surg. 2013;8:191.
23. Fuchs S, Kornowski R, Teplitsky I, Brosh D, Lev E, Vaknin-Assa H, *et al*. Major bleeding complicating contemporary primary percutaneous coronary interventions-incidence, predictors, and prognostic implications. Cardiovasc Revasc Med. 2009;10:88-93.
24. Nikolsky E, Mehran R, Dangas G, Fahy M, Na Y, Pocock SJ, *et al*. Development and validation of a prognostic risk score for major bleeding in patients undergoing percutaneous coronary intervention via the femoral approach. Eur Heart J. 2007;28:1936-45.
25. Ingremeau D, Grall S, Valliet F, Desprets L, Prunier F, Furber A, *et al*. Prognostic impact of body mass index on in-hospital bleeding complications after ST-segment elevation myocardial infarction. World J Cardiol. 2020;12:44-54.
26. Kim P, Dixon S, Eisenbrey AB, O'Malley B, Boura J, O'Neill W. Impact of acute blood loss anemia and red blood cell transfusion on mortality after percutaneous coronary intervention. Clin Cardiol. 2007;30:II35-43.
27. Shivashankarappa AB, Mahadevappa NC, Palakshachar A, Bhat P, Barthur A, Bangalore S, *et al*. Cerebrovascular events complicating cardiac catheterization - a tertiary care cardiac centre experience. Heart Views. 2021;22:264-70.
28. Alhumaidi WA, Alqurashi NN, Alnumani RD, Althagafi ES, Bajunaid FR, Alnefaie GO. Perceptions of doctors in Saudi Arabia toward virtual reality and augmented reality applications in healthcare. Cureus. 2023;15:e42648.
29. Seymour NE, Gallagher AG, Roman SA, O'Brien MK, Bansal VK, Andersen DK, *et al*. Virtual reality training improves operating room performance: Results of a randomized, double-blinded study. Ann Surg. 2002;236:458-63.
30. Palter VN, Grantcharov TP. Individualized deliberate practice on a virtual reality simulator improves technical performance of surgical novices in the operating room: A randomized controlled trial. Ann Surg. 2014;259:443-8.