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Comparison of distal and conventional transradial access on procedure duration and radiation exposure in carotid artery stenting

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Abstract

Objective This study aimed to assess the effects of distal transradial access (dTRA) compared to conventional transradial access (cTRA) on procedure duration and radiation exposure among patients undergoing carotid artery stenting.

Methods The study included 131 patients who underwent cerebrovascular interventional diagnosis and treatment in the Department of Cerebrovascular Diseases at Beijing Anzhen Hospital, Capital Medical University, from January 2022 to April 2024. Patients were categorized into dTRA and cTRA groups based on the puncture site. Clinical and laboratory data, operation duration, and the incidence of puncture-related complications and perioperative adverse events were recorded. Procedure duration and radiation exposure levels were then compared between the two groups.

Results The dTRA group comprised 47 patients and the cTRA group comprised 84 patients. No statistically significant differences were observed between the groups in terms of risk factors and laboratory parameters (all $P > 0.05$). Procedure-related comparisons between the dTRA and cTRA groups showed that the operation time for carotid artery stenting was (51.47 ± 10.51) minutes and (50.08 ± 11.37) minutes, respectively; the fluoroscopy time was (20.48 ± 5.55) minutes and (20.96 ± 9.24) minutes, respectively; and the radiation exposure dose was (573.60 ± 185.17) mGy and (567.09 ± 329.96) mGy, respectively. None of these differences were statistically significant (all $P > 0.05$).

Conclusion The results suggest that dTRA is comparable to cTRA in terms of procedure duration and radiation exposure during carotid artery stenting.

Keywords Carotid artery stenting, Conventional radial access, Distal radial artery access, Operation duration, Radiation exposure

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Introduction

Transradial access (TRA) has emerged a key approach for carotid artery stenting (CAS), with current guidelines recommending it as an alternative to transfemoral access (TFA), particularly in patients at elevated risk of complications associated with TFA (IIaB) [1–3]. Previous studies have reported a higher radial artery occlusion (RAO) rate with conventional transradial access (cTRA), which limits its repeated use [4–9]. Several large-scale randomized controlled trials (RCTs) and meta-analyses from coronary intervention have demonstrated an extremely low RAO rate and shorter hemostasis time after distal transradial access (dTRA), a method recommended by relevant consensus and guidelines [5–13]. Despite these findings, the application of dTRA in carotid artery stenting remains in its early stages, with several studies confirming its feasibility and safety [14, 15]. However, there is limited research comparing cTRA and dTRA in carotid artery stenting. Concerns regarding whether dTRA increases operation duration or radiation exposure have not been comprehensively investigated. This study aims to compare the operation duration and radiation exposure between dTRA and cTRA in carotid artery stenting, with the goal of providing additional data to guide clinical decision-making.

Participants and methods

Participants and study design

Between January 2022 and April 2024, 131 patients who underwent carotid artery stenting at the Department of Cerebrovascular Diseases, Beijing Anzhen Hospital, Capital Medical University, were enrolled in this study. The cohort consisted of 113 males and 18 females, with ages ranging from 47 to 85 years (mean age: 64.87 ± 7.12 years). The surgeons who performed carotid artery stenting were proficient in neurointerventional procedures via TRA and capable of managing intraoperative complications effectively. Each surgeon had performed an average of over 100 neurointerventional diagnosis and treatment procedures via TRA annually over the past three years. This study was conducted in accordance with the principles outlined in the Declaration of Helsinki and was approved by the Ethics Committee of Beijing Anzhen Hospital, Capital Medical University (approval number: 2023123X). Informed consent was obtained from all patients.

Inclusion and exclusion criteria

Inclusion criteria: (1) Patients with a confirmed diagnosis of stenosis at the origin of the internal carotid artery based on non-invasive imaging and cerebral angiography; (2) Patients with symptomatic internal carotid artery stenosis ≥ 50%, or asymptomatic internal carotid artery stenosis ≥ 70%; (3) Patients with a palpable distal radial artery and a negative Allen test result; `

Exclusion criteria: (1) Patients with acute cerebral infarction or acute myocardial infarction; (2) Patients with hemodynamic instability or severe hepatic and renal insufficiency; (3) Patients with coagulation dysfunction; (4) Patients requiring concurrent intracranial or other interventional treatment; (5) Patients with RAO or a positive Allen test result. All patients were interviewed by a neurointerventional physician before surgery, were fully informed about their condition, understood the diagnosis and treatment plan, and signed the informed consent form for digital subtraction cerebral angiography (DSA) and CAS.

Methods

The procedure was performed as follows: (1) Patients were positioned supine with the right upper limb naturally extended. The hand was disinfected up to the elbow and covered with sterile drapes. The puncture site for either dTRA or cTRA was selected. (2) Local anesthesia was administered using 1 to 2 mL of 1% lidocaine. A Terumo puncture needle was used to access the artery, followed by the insertion of a 6 F radial artery sheath. (3) A Loach guidewire and SIM- 2 catheter were employed for bilateral carotid angiography and vertebral arteriography. (4) For cases requiring stent placement, the Loach guidewire was used to guide a 5 F/6 F guide catheter to the lesion, followed by umbrella deployment, balloon dilation, stent implantation, and, if necessary, post-balloon dilation. (5) Following the procedure, the arterial sheath was removed, and compression was applied using sterile gauze rolls. Compression was gradually released every hour and the bandage was removed completely after 2 to 4 h.

Data collection

Data collection included the following parameters. General information: age, sex, smoking history, alcohol consumption, history of cerebral infarction/transient ischemic attack, hypertension, diabetes mellitus, hyperlipidemia, coronary heart disease, atrial fibrillation, and peripheral vascular disease). Clinical data: puncture site, puncture duration, operation duration, X-ray exposure time, and total radiation exposure. Complications: operation-related and puncture-related complications were recorded.

The risk factors observed in this study included age, sex, smoking, drinking, cerebral infarction/transient ischemic attack, hypertension, diabetes mellitus, hyperlipidemia, coronary heart disease, atrial fibrillation, and peripheral vascular disease. Information regarding smoking history and alcohol consumption was obtained from

the patient's medical records. Smoking was defined as either current smoking or former smoking; if smoking status was not documented, the patient was classified as a smoker. The same criteria was applied for alcohol consumption.

Hypertension was defined as either a previous diagnosis of hypertension or a systolic blood pressure ≥130 mmHg (1 mmHg =0.133 kPa) and/or diastolic blood pressure ≥80 mmHg upon admission, or the patient being on antihypertensive medication [9]. Diabetes mellitus was defined as a confirmed history of diabetes prior to admission, or a glycosylated hemoglobin level ≥6.5%, fasting blood glucose ≥7.0 mmol/L, or a 2-h postprandial blood glucose ≥11.0 mmol/L after admission. Hyperlipidemia was defined as a documented history of dyslipidemia, current use of lipid-lowering medications, or a low-density lipoprotein cholesterol level of ≥2.6 mmol/L [11].

Puncture duration was defined as the time from room entry to the first image frame obtained after puncture. Operation duration was the time interval between the first and last image frames during the procedure. X-ray exposure duration and total radiation exposure values were obtained from the PACS system.

Grouping

Patients were categorized into the cTRA group or the dTRA group based on the different puncture sites. The cTRA group comprised patients who experienced failure of the initial dTRA puncture or sheath insertion and were subsequently switched to ipsilateral TRA or contralateral TRA. General data, laboratory tests, and clinical information between the two groups were compared and analyzed. The patients were followed up until discharge to monitor the occurrence of complications such as puncture site bleeding, oozing, and bruising. Additionally, perioperative adverse events, including cerebral hemorrhage, cerebral infarction, myocardial infarction, and all-cause mortality, were recorded.

Statistical analysis

All data were analyzed using SPSS 25.0 statistical software. Categorical variables are expressed as frequencies and percentages, with group comparisons conducted using the chi-squared test. Continuous variables are presented as mean ± standard deviation ($\bar{x} \pm s$), and differences between groups were evaluated using the *t*-test. Statistical significance was defined as $P < 0.05$.

Results

The general clinical characteristics of the study population are summarized as follows: A total of 131 patients were enrolled, with ages ranging from 47 to 85 years and an average age of 64.92 ± 7.22 years. Among them, 113 were males (86.3%) and 18 were females (13.7%). In terms of lifestyle factors, 79 (60.3%) were smokers, and 50 (38.2%) were drinkers. Additionally, 42 (32.1%) had a history of cerebral infarction, 88 (67.4%) had hypertension, 53 (40.5%) had diabetes mellitus, 91 (69.5%) had hyperlipidemia, and 55 (42.0%) had coronary heart disease.

Comparative analysis of risk factors and laboratory indicators between groups

A total of 47 (35.9%) patients were enrolled in the dTRA group, while 84 (64.1%) patients were enrolled in the cTRA group. Comparison of risk factors between the two groups showed no significant differences in age, sex, smoking, hypertension, diabetes mellitus, hyperlipidemia, atrial fibrillation, or peripheral vascular disease (all $P > 0.05$). However, the proportion of patients with a history of cerebral infarction was significantly higher in the cTRA group (40.5% vs 17.0%, $P = 0.006$) (Table 1).

The comparison of laboratory indicators showed no significant differences between the two groups (all $P > 0.05$). The basic clinical data of the two patient groups were comparable (Table 2).

Comparison of operation duration and radiation indexes between cTRA and dTRA groups

Comparison of operation-related indexes between the dTRA and cTRA groups indicated the following: the operation time was (51.47 ± 10.51) minutes in the dTRA group and (50.08 ± 11.37) minutes in the cTRA group; the fluoroscopy time was (20.48 ± 5.55) minutes in the dTRA group and (20.96 ± 9.24) minutes in the cTRA group; and the radiation exposure dose was (573.60 ± 185.17) mGy in the dTRA group and (567.09 ± 329.96) mGy in the cTRA

Table 1 Comparison of risk factors between the dTRA and cTRA groups

Puncture site	dTRA (*N* = 47)	cTRA (*N* = 84)	*P* value
Age	65.51 ± 6.672	64.58 ± 7.521	0.704
Male	38(80.9%)	9(50.0%)	0.179
Smoking history	27(57.4%)	52(61.9%)	0.617
Drinking history	20(42.6%)	30(35.7%)	0.440
Medical history			
Cerebral infarction	8(17.0%)	34(40.5%)	0.006
Hypertension	32(68.1%)	56(66.7%)	0.868
Diabetes mellitus	20(42.6%)	33(39.3%)	0.715
Hyperlipidemia	37(78.7%)	54(64.3%)	0.085
Coronary heart disease	21(44.7%)	34(40.5%)	0.640
Atrial fibrillation	0(0.0%)	6(7.1%)	0.087
Peripheral vascular disease	2(4.3%)	2(2.4%)	0.550

Table 2 Comparison of laboratory indicators between the cTRA and dTRA groups

	dTRA (*N* = 47)	cTRA (*N* = 84)	*T* value	*P* value
WBC	6.68 ± 1.68	6.52 ± 1.70	0.501	0.617
RBC	6.11 ± 10.63	4.55 ± 0.56	1.342	0.182
HB	141.78 ± 14.53	144.66 ± 39.13	− 0.485	0.628
PLT	222.82 ± 62.64	212.69 ± 67.86	0.843	0.401
AST	19.17 ± 5.49	21.48 ± 12.28	− 1.225	0.223
ALT	20.27 ± 9.69	26.32 ± 21.76	− 1.804	0.073
Total protein	66.88 ± 9.53	66.70 ± 9.32	0.105	0.917
Albumin	44.48 ± 13.86	45.90 ± 11.26	− 0.637	0.525
CREA	75.61 ± 17.92	81.31 ± 20.01	− 1.621	0.108
UA	316.61 ± 89.70	329.19 ± 80.45	− 0.823	0.412
GLU	6.08 ± 1.8	5.88 ± 1.69	0.638	0.524
TG	1.58 ± 0.94	1.50 ± 0.65	0.544	0.587
TC	3.78 ± 1.12	3.77 ± 0.94	0.067	0.947
HDL-C	3.91 ± 19.98	1.03 ± 0.24	1.324	0.188
LDL-C	2.14 ± 0.97	2.09 ± 0.74	0.335	0.738
HCY	14.61 ± 4.97	16.59 ± 10.01	− 1.254	0.212

Table 3 Comparison of Operation Duration Between the dTRA and cTRA Groups

Puncture site	dTRA(*N* = 47)	cTRA(*N* = 84)	*T* value	*P* value
Puncture time	18.77 ± 8.41	17.32 ± 8.91	0.908	0.366
Operation duration	51.47 ± 10.51	50.08 ± 11.37	0.687	0.494
X-ray exposure dose	573.60 ± 185.17	567.09 ± 329.96	0.125	0.901
Radiation exposure time	20.48 ± 5.55	20.96 ± 9.24	.– 0.327	0.744

group. There were no statistically significant differences between the two groups (all $P > 0.05$) (Table 3).

Follow-up

There were 5 cases of bruising at the puncture site in the cTRA group and 1 case in the dTRA group ($\chi^2 = 1.107$, $P = 0.293$). No cases of cerebral hemorrhage, cerebral infarction, myocardial infarction, or other perioperative events were observed in either group.

Discussion

TRA has emerged as a safe, comfortable, and cost-effective approach for interventional procedures [1, 16–18]. It has been endorsed by the American Heart Association as the preferred access route for coronary angiography and interventional therapy (Class I recommendation, Class A evidence) and is also suitable for most neurointerventional procedures, reflecting its growing clinical acceptance [11, 13, 19–21]. Current studies indicate no significant differences in surgical success rates, operation time, complications, or length of hospital stay between TFA and TRA for carotid artery stenting [1, 21, 22]. The 2023 European Society for Vascular Surgery (ESVS) guidelines recommend radial artery revascularization as an alternative to TFA stenting, particularly when TFA presents a higher risk of complications. TRA is preferred when both TFA and TRA carotid stenting are viable options [2].

However, the occurrence of RAO following cTRA is relatively high, drawing increasing clinical attention in recent years, with a prevalence ranging from 0.8% to 38% (average rate of 5–10%) [4]. RAO limits the ability to reuse the radial artery, affects access selection, and alters treatment strategies for subsequent interventional procedures, in addition to excluding the option of using the radial artery as a'bypass conduit'in the future. Numerous studies from both cardiovascular and neurointerventional fields have shown a significant reduction in RAO after dTRA, along with shorter postoperative compression times, fewer complications, and greater patient comfort [23–26]. This is particularly beneficial for neurointerventional patients who require oral anticoagulation or anti-platelet therapy. Furthermore, it offers an ergonomic advantage for patients needing left-sided access and those with limited arm supination [12]. The Korean-European expert consensus has recommended dTRA as a promising alternative to cTRA [12].

Currently, the adoption rate of dTRA remains low. Concerns regarding the high radiation dose and extended operation time for both the surgeon and patient are significant factors impeding the widespread use of dTRA [27]. Additionally, comparative studies and data analyses of radiation-related indicators between various access sites, such as the radial and femoral arteries, as well as the distal and proximal radial arteries, have produced inconsistent results in both coronary artery interventions and neurointerventions [20, 28]. As a result, it remains unclear whether dTRA leads to increased operation duration and radiation exposure [27, 29].

Hoffman et al., from the Department of Neurosurgery, State University of New York, conducted a retrospective study comparing the safety, efficacy, and operational characteristics of proximal and distal radial artery accesses for diagnostic cerebral angiography [14]. The study included 244 patients and 287 instances of diagnostic angiography. The results indicated that both dTRA and cTRA were equally safe and effective, with no significant differences in operation duration, time to entry and exit, or time to hospital discharge. However, statistically significant differences were observed in fluoroscopy time and radiation dose. The average fluoroscopy

time for the cohort was 10.53 ± 6.24 min, with cTRA having a shorter fluoroscopy time compared to dTRA (95% CI: − 4.18 to − 0.90, $P = 0.003$). The mean radiation dose for the cohort was 576.14 ± 391.69 mGy, and cTRA exhibited a lower radiation dose compared to dTRA (95% CI: − 351.55 to − 134.24, $P < 0.001$), with significant statistical differences.

There are no comparative studies on the radiation dose and operation duration between cTRA and dTRA for CAS, either domestically or internationally. In this study, the surgical data for dTRA and cTRA in CAS were retrospectively analyzed, and no statistically significant differences were found in puncture time, operation duration, radiation dose, or fluoroscopy time between the two approaches.

There was no statistically significant difference in puncture time between the two groups in this study, likely because the puncture time in the proximal radial artery group included the time required to switch to proximal radial puncture after an unsuccessful distal radial artery attempt. Additionally, the comparison of risk factors between the two groups indicated that the proportion of patients with a history of cerebral infarction was higher in the cTRA group (40.5% vs. 17.0%, $P = 0.006$), which was statistically significant. This may be attributed to patients with a history of cerebral infarction having slightly reduced cooperation, resulting in a lower success rate for distal radial artery puncture.

There are several limitations of this study. First, the study is a small, single-center retrospective analysis; second, the sample selection is limited. In the future, we plan to expand the sample size based on the existing experience, design randomized controlled trials, and collaborate with additional neurointerventional centers. In addition, this retrospective study did not explicitly exclude cases where dTRA was attempted before cTRA puncture, and the number of patients who experienced crossover from dTRA to cTRA were not counted. While our results showed that the cTRA group had a shorter puncture time (with no significant difference), future studies accounting for this limitation are needed to confirm these findings. Lastly, ultrasound examination was performed only when the radial artery pulse was not palpable at discharge.

In conclusion, this study suggests that, after considering the learning curve (with both surgeons having performed over 300 TRA surgeries annually), the longer surgical access required for dTRA compared to cTRA did not lead to a significant increase in operation duration or radiation dose.

Abbreviations

dTRA	Distal transradial access
cTRA	Conventional transradial access
TRA	Transradial access
CAS	Carotid artery stenting
RAO	Radial artery occlusion
cTRA	Conventional transradial access
RCTs	Randomized controlled trials
DSA	Digital subtraction cerebral angiography
ESVS	European Society for Vascular Surgery

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Clinical trial number
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Authors' contributions
Conception and design of the research: Lifeng Wang Xu Guo Acquisition of data: Xia Ma, Xiaofen He, Zhe Song Analysis and interpretation of the data: Lifeng Wang,Xu Guo,Xiaoping Zhang Statistical analysis: Xia Ma, Xiaofen He, Zhe Song, Xiaoping Zhang Writing of the manuscript: Lifeng Wang Xiaoping Zhang Critical revision of the manuscript for intellectual content: Lifeng Wang Xu Guo All authors read and approved the final draft.

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Data availability
The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the declaration of Helsinki.This study was conducted with approval from the Ethics Committee of Beijing Anzhen Hospital. A written informed consent was obtained from all participants.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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