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Abstract

***Purpose*:** Carotid endarterectomy (CEA) can effectively manage carotid plaques and has evolved over the past 70 years. However, it cannot be applied to all tandem carotid lesions owing to their wide variability. Herein, we introduce an innovative approach to CEA, termed Triple eversion CEA, for the treatment of tandem carotid lesions.

Methods: In this cross-sectional study, we retrospectively reviewed the charts of patients who underwent Triple eversion CEA performed by the same vascular surgeons between 17 September 2021 and 20 September 2024.

***Results*:** Eleven male symptomatic patients, with an average age of 72.2 ± 9.3 years, were included in this study. The patients exhibited comorbidities, including diabetes, hypertension, coronary heart disease, peripheral vascular disease, and cerebral infarction. All patients underwent computed tomography angiography and/or digital subtraction angiography pre-surgery. Internal and external carotid arteries were transected at the carotid bifurcation, followed by eversion endarterectomy for plaque removal. The mean operative time was 123.2 ± 35.5 min, with a mean primary clamping time of 27.5 ± 6.5 min and intraoperative blood loss of 36.4 ± 13.6 mL. The postoperative drainage tube indwelling time was 43.6 ± 6.7 h, with a drainage volume of 39.7 ± 3.4 mL. During the follow-up of 24.2 ± 11.8 months, no deaths or complications, such as cerebral infarction, cerebral haemorrhage, or myocardial infarction,

occurred.

***Conclusions*:** Triple eversion CEA, designed for tandem carotid lesions, can treat long-segment plaques in the external and common carotid arteries.

Keywords: carotid artery stenosis, carotid endarterectomy, Triple eversion carotid endarterectomy, tandem carotid lesion

1. Introduction

Carotid artery stenosis (CAS) is a life-threatening condition that leads to blood flow obstruction and an increased risk of stroke [1,2]. With improved living standards and increased lipid intake, the detection rate of CAS has increased. Cardiovascular risk factors such as hypertension, diabetes, dyslipidaemia, and smoking are closely linked to the incidence of carotid artery disease [3]. Stenosis of the extracranial segment of the carotid artery mostly occurs at the bifurcation of the carotid artery. Extracranial tandem carotid lesions (TCLs) refer to ≥ 2 severe stenoses or occlusions at multiple locations in the carotid artery [4]. TCLs typically require surgical intervention; however, they remain challenging to treat with conventional carotid endarterectomy (CEA), as the plaque cannot be completely removed [5]. Stenosis in the common carotid artery (CCA) and internal carotid artery (ICA) accounts for approximately 5% of all reported CAS cases [6,7].

TCLs cause more significant changes in carotid artery haemodynamics than single stenotic lesions, severely attenuating cerebral blood supply. TCLs also involve longer plaques, a wider range of lesions, longer intraoperative blockage times, and an increased risk of cerebral infarction, all placing higher technical demands on surgeons [8]. TCLs account for 15–20% of acute ischaemic stroke cases involving large vessel occlusions [9-12]. Consequently, surgery should be performed promptly following TCL diagnosis and exclusion of contraindications.

Although CEA has improved [13], it remains inadequate to treat TCLs owing to its inability to address long segments of the CCA and external carotid artery (ECA) plaques [14]. The introduction of double eversion CEA (DECE) in 2013 partially resolved this problem [15]. However, treating ECA plaques remains unsatisfactory, although it is necessary given that the ECA plays a vital role in blood flow to the face and head. Herein, we introduce Triple eversion (TE)-CEA, a novel variant of CEA and DECE, for treating TCLs.

2. Materials and Methods

From 17 September 2021 to 20 September 2024, 11 patients with TCLs underwent TE-CEA in our department. Patients were treated with antiplatelet drugs (aspirin, 100 mg/day) daily before surgery to reduce the risk of thrombus formation. The duration of antiplatelet therapy was calculated based on the date of hospitalisation; therefore, it varied among the patients. Patient characteristics (sex, age at operation, symptoms, indication for treatment, comorbidities, preoperative imaging, and lesion characteristics), operative details (total operative time, clamping time, and intraoperative blood loss), and postoperative observations (indwelling time of the drainage tube, drainage volume, complications, and follow-up) were recorded. We contacted patients every 2 months to enquire about their postoperative recovery and conducted regular computed tomography angiography (CTA) reviews to assess carotid artery recanalisation. The primary outcome was postoperative recovery, and the secondary outcome was the development of postoperative complications.

We included patients who (1) met the following CEA surgical criteria: asymptomatic CCA and ICA stenosis >70% or symptomatic CAS >50% as confirmed by digital subtraction angiography (DSA) or CTA before surgery; (2) exhibited severe ICA stenosis combined with severe CCA stenosis (the length of plaque longer than 5 cm); and (3) experienced or did not experience severe ECA stenosis.

Conversely, we excluded patients who (1) did not meet the CEA surgical criteria, (2) experienced asymptomatic CAS <50% (confirmed by DSA or CTA before surgery), or (3) exhibited narrow CCA openings.

2.1 Techniques

TE-CEA was performed as follows: After the induction of general anaesthesia, the patient was positioned supine with the neck in 30° extension, and the head was rotated to the opposite side

to ensure adequate exposure to the surgical target. This is critical for the success of the surgery. An oblique incision was made at the anterior edge of the sternocleidomastoid muscle, and the skin, subcutaneous fat, and platysma were incised in layers. The carotid sheath was dissected in front of the sternocleidomastoid muscle to expose sufficient lengths of the CCA, ECA, and ICA arteries. After raising the systolic blood pressure to 180 mmHg and intravenously injecting 125 units/kg of heparin, the superior thyroid artery was ligated and severed. The CCA was occluded proximal to the plaque based on the plaque location indicated by preoperative CTA and intraoperative arterial exploration. Subsequently, the ECA and ICA were clamped individually (Figure 1A). The ICA was transected diagonally at the CCA bifurcation, and the ECA was transected approximately 5 mm above its origin (Figure 1B). Using forceps, the plaque was removed after ICA eversion, and the process was repeated for the ECA. Finally, the long segment of the plaque in the CCA was stripped proximally, followed by thoroughly removing the debris on the peeling surface using heparin irrigation (Figure 1C). End-to-side anastomosis of the ICA and CCA was performed using a 6-0 Prolene suture. After expelling the gas and debris through the ECA port, the occluding forceps on the CCA and ICA were removed to restore the blood supply to the brain (Figure 1D). End-to-end anastomosis was performed at the origin of the ECA following adequate gas and debris removal (Figure 1E). After confirming good pulsation in the ICA, CCA, and ECA, protamine was introduced at 1:2 to neutralise heparin. Meanwhile, blood pressure was maintained to prevent brain hyperperfusion injury by ensuring the systolic blood pressure was less than 120 mmHg. Finally, a drainage tube was placed in the wound, which was sutured layer by layer.

2.2 Data handling

This study mainly used descriptive statistical methods, expressed as the mean ± standard deviation. All data were analysed using GraphPad Prism 10.0 statistical software (GraphPad

Inc., La Jolla, CA, USA).

2.3 Ethical approval

All procedures were conducted in compliance with relevant laws and institutional guidelines and in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. The study was approved by the Human Research Ethics Committee of the Second Affiliated Hospital of Zhejiang University School of Medicine (Approval No. 2024-1297). This trial was registered at https://www.clinicaltrials.gov/ under the registration number NCT06722222. Informed consent was obtained from all participants.

3. Results

This study enrolled 11 male patients who underwent TE-CEA between 17 September 2021 and 24 September 2024. The average age of the patients was 72.2 ± 9.3 years, and all patients experienced pre-surgery symptoms, including dizziness, memory loss, blurred vision, and tinnitus. Additionally, patients had comorbidities that included diabetes, hypertension, coronary heart disease, peripheral vascular disease, and cerebral infarction (Table 1). Patients underwent CTA and/or DSA before the surgery. The lesion characteristics and operative details are presented in Table 2. The mean operative time was 123.2 ± 35.5 min, with a mean primary clamping time of 27.5 ± 6.5 min and intraoperative blood loss of 36.4 ± 13.6 mL. The postoperative drainage tube indwelling time was 43.6 ± 6.7 h, with a drainage volume of 39.7 ± 3.4 mL. Plaques in the ICA, ECA, and CCA were thoroughly cleaned and photographed post-removal (Figure 2). Postoperative CTA of the carotid arteries was also performed. Compared with the preoperative condition, the plaque in the stenotic region was effectively removed, blood flow was restored, and CAS-related symptoms were relieved (Figure 3).

During the mean follow-up period of 24.2 ± 11.8 months, no deaths or complications, such as

158 cerebral infarction, cerebral haemorrhage, or myocardial infarction, were observed. Only three
159 patients reported symptoms of wound numbness during postoperative evaluation.
160
161 **4. Discussion**
162 Whereas CEA remains a cornerstone in treating CAS, potential complications remain. The
163 major risks associated with CEA include stroke, myocardial infarction, and even death,
164 necessitating alternative approaches, particularly in challenging cases. Although accurate
165 epidemiological data are lacking, our recent clinical experience indicates that the number of
166 patients diagnosed with TCLs is increasing. Owing to the inefficacy of traditional CEA as a
167 surgical treatment for these lesions, novel surgical techniques are urgently needed.
168 Traditional CEA was first used clinically in 1953 by Professor DeBakey at Baylor University
169 [6]. Following further improvements by Professor Raithel, CEA has become a standard surgical
170 method with a short clamping time and low anastomotic re-stenosis rate, ensuring considerable
171 safety and efficacy [16]. However, CEA possesses inherent drawbacks. First, it cannot be used
172 to treat long segments of CCA plaques. With the increasing incidence of TCLs, vascular
173 surgeons have been exploring new surgical methods, among which DECE has attracted
174 attention. DECE partially resolves these problems, as the ICA and long segments of CCA
175 plaques are removed through double eversion of the ICA and CCA. However, plaque in the
176 ECA cannot be removed, and the clamping time is prolonged [15].
177 The traditional eversion technique has advantages in dealing with ICA, but it is limited in
178 handling long-segment CCA and ECA. Our surgical approach retains the advantages of the
179 traditional eversion technique and expands the surgical techniques of CCA and ECA. Based on
180 over 25 years of clinical experience, we meticulously developed TE-CEA to treat TCLs.
181 Compared with previously reported techniques, TE-CEA possesses three major advantages.
182 First, it enables complete eversion and removal of plaques from the ICA, ECA, and CCA,

reducing the risk of recurrence and enhancing long-term outcomes. Second, anastomosis is performed rapidly, minimising the likelihood of postoperative re-stenosis. By first completing ICA anastomosis and then promptly releasing the clamps on the CCA and ICA to restore cerebral blood flow, the carotid clamping time is not markedly extended. Third, the procedure places particular emphasis on removing ECA plaques, crucial for the comprehensive restoration of the cerebral blood supply.

While the Vollmar ring is used to treat peripheral atherosclerotic lesions, its use in the CCA to manage complete occlusions has been noted in a limited number of reports [17,18]. In contrast, TE-CEA does not utilise the Vollmar ring. Instead, it relies on direct dissection using forceps. This approach avoids excessive CCA stripping that can lead to arterial wall thinning, potentially triggering early or late pseudoaneurysm formation. However, TE-CEA places higher demands on the technical skills and experience of surgeons. Precise incision placement in the ICA and ECA is crucial, and eversion and dissection must be completed swiftly to minimise cerebral ischaemia. All 11 surgeries reported herein were performed by the same surgeon with 25 years of experience, including 1,000 carotid surgeries, and focused on improving carotid surgery since 2010. The assistant surgeons possessed an average of 15 years of experience.

The occurrence of postoperative complications, such as stroke, heart attack, surgical infection, hoarseness, and dysphagia, is low following traditional CEA [19]. None of the patients in this study developed these complications owing to the long-term clinical experience of our clinical team; three patients reported wound numbness. Clamping time has been identified as a key factor affecting postoperative complications [20]. The clamping time in DECE was 29.2 (27–56) min, similar to that in TE-CEA (27.5 ± 6.5 min) [15]. Hence, our surgical approach eliminates plaque in the ECA without increasing clamping time.

We aimed to promote an improved version of the operation based on CEA. Next, we plan to

promote this technology in multiple centres worldwide. We believe that this novel surgical approach has the potential to benefit a broader population of patients with TCLs.

4.1 Limitations

Owing to the strict selection of study participants and the novelty of the surgery, our study was limited to a relatively small sample size with no control group of similar patients. Therefore, future studies with larger sample sizes, adequate controls, and longer follow-up periods are required to establish the efficacy of TE-CEA. Second, our study was limited to our hospital and lacked multicentre data. Third, the observed outcomes might have been influenced by the specific expertise of the surgeons involved, potentially limiting the immediate applicability of the technique in centres with surgeons of varying levels of experience. Therefore, multicentre studies with varying levels of expertise are required to validate our results and establish the broader applicability of TE-CEA across different healthcare systems and patient demographics. Finally, sex may represent a potential bias in our study, as all participants were males. Future studies should include female patients to validate the beneficial effects of TE-CEA.

5. Conclusions

This preliminary clinical study revealed the safety of the TE-CEA procedure when performed under strict and regulated surgical management by skilled CEA surgeons. Compared with traditional CEA, TE-CEA is more effective for treating TCLs, as it can address the ECA and long-segment plaques in the CCA. This study provides evidence supporting the potential of TE-CEA as a promising technique for managing TCLs, although further investigation remains warranted. Multicentre randomised controlled trials with larger and more diverse patient populations are needed to validate the safety and efficacy of TE-CEA in treating TCLs.

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Author contributions:

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References

[1] J. Smith, D. Margalit, J. Golledge, D. Nastasi, A. Nohria, L. McDowell, Carotid artery stenosis and ischemic stroke in patients with head and neck cancer treated with radiation therapy: A critical review, Int. J. Radiat. Oncol. Biol. Phys. 119 (2024) 1437–1454. https://doi.org/10.1016/j.ijrobp.2024.03.044.

[2] L. Li, P.R. Krafft, N. Zeng, R. Duan, X. Qi, A. Shao, F. Xue, J.H. Zhang, Microglia autophagy mediated by TMEM166 promotes ischemic stroke secondary to carotid artery stenosis, Aging Dis. 15 (2024) 1416–1431. https://doi.org/10.14336/AD.2023.0803.

[3] L. Saba, R. Cau, R. Vergallo, M.E. Kooi, D. Staub, G. Faa, T. Congiu, G. Ntaios, B.A. Wasserman, J. Benson, V. Nardi, R. Kawakami, G. Lanzino, R. Virmani, P. Libby, Carotid artery atherosclerosis: mechanisms of instability and clinical implications, Eur. Heart J. 46 (2025) 904–921. https://doi.org/10.1093/eurheartj/ehae933.

[4] F.M. Siddiqui, A.E. Hassan, N. Tariq, H. Yacoub, G. Vazquez, M.F. Suri, R.A. Taylor, A.I. Qureshi, Endovascular management of symptomatic extracranial stenosis associated with secondary intracranial tandem stenosis. A multicenter review, J. Neuroimaging. 22 (2012) 243–248. https://doi.org/10.1111/j.1552-6569.2011.00611.x.

[5] G. Illuminati, G. Pizzardi, R. Pasqua, F. Frezzotti, P. Palumbo, F. Macrina, F. Calio', Hybrid treatment of tandem, common carotid/innominate artery and ipsilateral carotid bifurcation stenoses by simultaneous, retrograde proximal stenting and eversion carotid endarterectomy: preliminary results of a case series, Int. J. Surg. 52 (2018) 329–333. https://doi.org/10.1016/j.ijsu.2018.02.062.

[6] E.S. Crawford, M. Debakey, W.S. Fields, G.C. Morris Jr., D.A. Cooley, Surgical considerations in the treatment of cerebral arterial insufficiency; scientific exhibit, Postgrad. Med. 26 (1959) 227–237. https://doi.org/10.1080/00325481.1959.11712569.

[7] P.A. Rouleau, J. Huston 3rd, J. Gilbertson, R.D. Brown Jr., F.B. Meyer, T.C. Bower, Carotid

artery tandem lesions: frequency of angiographic detection and consequences for endarterectomy, AJNR Am. J. Neuroradiol. 20 (1999) 621–625.

[8] V. Cvetic, M. Dragas, M. Colic, I. Vukasinovic, O. Radmili, N. Ilic, I. Koncar, V. Bascarevic, N. Ristanovic, L. Davidovic, Simultaneous endovascular treatment of tandem internal carotid lesions: case report and review of literature, Vasc. Endovasc. Surg. 50 (2016) 359–362. https://doi.org/10.1177/1538574416652246.

[9] M. Anadani, A.M. Spiotta, A. Alawieh, F. Turjman, M. Piotin, D.C. Haussen, R.G. Nogueira, P. Papanagiotou, A.H. Siddiqui, B. Lapergue, F. Dorn, C. Cognard, M. Ribo, M.N. Psychogios, M.A. Labeyrie, M. Mazighi, A. Biondi, R. Anxionnat, S. Bracard, S. Richard, B. Gory; TITAN (Thrombectomy In TANdem Lesions) Investigators, Emergent carotid stenting plus thrombectomy after thrombolysis in tandem strokes: analysis of the Titan registry, Stroke 50 (2019) 2250–2252. https://doi.org/10.1161/STROKEAHA.118.024733.

[10] Z. Assis, B.K. Menon, M. Goyal, A.M. Demchuk, J. Shankar, J.L. Rempel, D. Roy, A.Y. Poppe, V. Yang, C. Lum, D. Dowlatshahi, J. Thornton, H. Choe, P.A. Burns, D.F. Frei, B.W. Baxter, M.D. Hill; ESCAPE Trialists, Acute ischemic stroke with tandem lesions: technical endovascular management and clinical outcomes from the Escape trial, J. Neurointerv. Surg. 10 (2018) 429–433. https://doi.org/10.1136/neurintsurg-2017-013316.

[11] M. Goyal, B.K. Menon, W.H. van Zwam, D.W.J. Dippel, P.J. Mitchell, A.M. Demchuk, A. Dávalos, C.B. Majoie, A. van der Lugt, M.A. de Miquel, G.A. Donnan, Y.B. Roos, A. Bonafe, R. Jahan, H.C. Diener, L.A. van den Berg, E.I. Levy, O.A. Berkhemer, V.M. Pereira, J. Rempel, M. Millán, S.M. Davis, D. Roy, J. Thornton, L.S. Román, M. Ribó, D. Beumer, B. Stouch, S. Brown, B.C. Campbell, R.J. van Oostenbrugge, J.L. Saver, M.D. Hill, T.G. Jovin; HERMES collaborators, Endovascular thrombectomy after large-vessel ischaemic stroke: a meta-analysis of individual patient data from five randomised trials, Lancet 387 (2016) 1723–1731. https://doi.org/10.1016/S0140-6736(16)00163-X.

[12] M. Marko, P. Cimflova, A.Y. Poppe, N. Kashani, N. Singh, J. Ospel, A. Mayank, B. van Adel, R.A. McTaggart, R.G. Nogueira, A.M. Demchuk, J.L. Rempel, M. Joshi, C. Zerna, B.K. Menon, M. Tymianski, M.D. Hill, M. Goyal, M.A. Almekhlafi; ESCAPE-NA1 investigators, Management and outcome of patients with acute ischemic stroke and tandem carotid occlusion in the Escape-NA1 trial, J. Neurointerv. Surg. 14 (2022) neurintsurg-2021-017474. https://doi.org/10.1136/neurintsurg-2021-017474.

[13] L.B. Davidovic, I.Z. Tomic, Eversion carotid endarterectomy : A short review, J. Korean Neurosurg. Soc. 63 (2020) 373–379. https://doi.org/10.3340/jkns.2019.0201.

[14] C.D.Q. Flumignan, R.L.G. Flumignan, T.P. Navarro, Extracranial carotid stenosis: evidence based review, Rev. Col. Bras. Cir. 44 (2017) 293–301. https://doi.org/10.1590/0100-69912017003012.

[15] Y. Georg, E. Psathas, F. Alomran, J. Gaudric, L. Chiche, F. Koskas, Double eversion carotid endarterectomy of tandem carotid lesions, Ann. Vasc. Surg. 28 (2014) 1186–1191. https://doi.org/10.1016/j.avsg.2013.07.018.

[16] D. Raithel, Intraoperative angioscopy after carotid endarterectomy, J. Mal. Vasc. 18 (1993) 258–261.

[17] E.T. Aguiar, A. Lederman, P. Matsunaga, Ring-stripping retrograde common carotid endarterectomy: case report, Sao Paulo Med. J. 120 (2002) 154–157. https://doi.org/10.1590/s1516-31802002000500007.

[18] L. Pintér, C. Cagiannos, C.N. Bakoyiannis, R. Kolvenbach, Hybrid treatment of common carotid artery occlusion with ring-stripper endarterectomy plus stenting, J. Vasc. Surg. 46 (2007) 135–139. https://doi.org/10.1016/j.jvs.2007.01.062.

[19] Y. Ito, W. Tsuruta, Y. Nakai, T. Takigawa, A. Marushima, T. Masumoto, Y. Matsumaru, E. Ishikawa, A. Matsumura, Treatment strategy based on plaque vulnerability and the treatment risk evaluation for internal carotid artery stenosis, Neurol. Med. Chir. (Tokyo) 58 (2018) 191–

198. https://doi.org/10.2176/nmc.oa.2017-0228.

[20] R.D. Weisel, F.B. Hoy, R.J. Baird, R.J. Burns, D.A. Mickle, J. Ivanov, M.M. Madonik, P.R. McLaughlin, Improved myocardial protection during a prolonged cross-clamp period, Ann. Thorac. Surg. 36 (1983) 664–674. https://doi.org/10.1016/s0003-4975(10)60275-5.

334 **Table 1** Comorbidities and main risk factors

Comorbidity or risk factor	Number	%
Symptomatic (ipsilateral TIA or stroke)	3	27.3
Hypertension	7	63.6
Diabetes	2	18.2
Smoking	11	100
Gout	3	27.3
Hyperlipidaemia	1	9.1
CAD	5	45.5

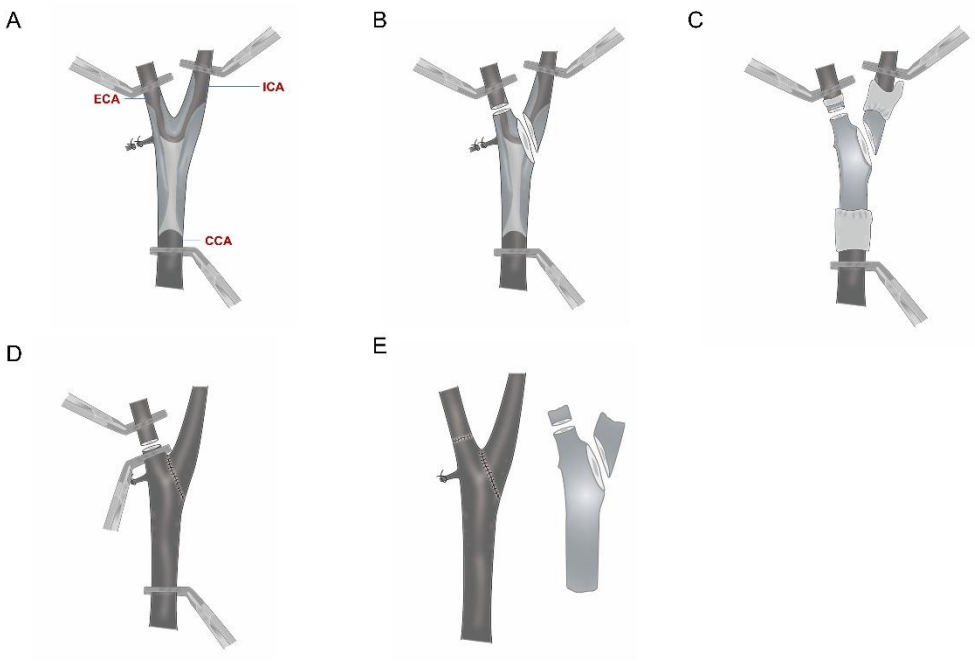
335 TIA, transient ischaemic attack; CAD, coronary artery disease

336

Table 2 Lesion characteristics and operative details

Perioperative parameter	Mean ± SD
Operation time (min)	123.2±35.5
Clamping time (min)	27.5±6.5
Intraoperative blood loss (mL)	36.4±13.6
Drainage tube indwelling time (h)	43.6±6.7
Drainage volume (mL)	39.7±3.4
Follow-up (months)	12
Complications or death	0

SD, standard deviation



358

359 Figure 1



360

361 Figure 2



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363 Figure 3