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MORPHOMETRIC AND MORPHOLOGICAL ASSESSMENT OF CORONARY ARTERIES WITH INTRAVASCULAR ULTRASOUND

DOI: 10.36740/WLek202302109

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ABSTRACT

The aim: To perform a morphometric assessment of the coronary arteries ostia by intravascular ultrasound with morphological evaluation among the Ukrainian population.

Materials and methods: Intravascular images of the ostia of the right (48%) and left (52%) coronary arteries with the minimum diameter, maximum diameter, mean diameter and lumen area were analyzed. An intravascular ultrasound procedure was performed before percutaneous intervention.

Results: A total of 25 IVUS examinations were collected from patients of both sexes and the same ages: 61,27±10,24 for males and females 68±5,83 (p=0.64). The left coronary artery (LCA) ostium assessment was performed in 13 (52%) cases: 8 men and 5 women (32% and 20%, respectively). The right coronary artery (RCA) ostium assessment was performed in 12 (48%) cases: 7 men and 5 women (28% and 20%, respectively). The maximal diameter of the coronary artery ostia was higher in men (5.95±0.66mm) than in women (4.82±0.34mm) ($p<0.0001$). In men, the maximal diameter of the RCA was higher than in the LCA (6.4±0.40mm and 5.56±0.60mm, respectively). The same differences were found in the mean diameter and lumen area ($p<0.05$). In women, the minimum diameter, mean diameter, maximum diameter and lumen area of the RCA were higher than LCA but without statistically significant differences. The anatomic precondition explains the observed changes in echogenicity.

Conclusions: IVUS analysis shows significantly higher parameters of the minimum diameter, mean diameter, maximum diameter and lumen area in men than in women among the Ukrainian population. Therefore, morphological evaluation is crucial in the interpretation of intracoronary images.

KEY WORDS: anatomy, intravascular ultrasound, IVUS, coronary vessels, intravascular ultrasonography

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INTRODUCTION

Intravascular ultrasound (IVUS) is a modern method of visualizing the coronary arteries from the lumenal surface of the vessel [1]. The cross-sections of the intracoronary images make possible the measuring of the coronary artery size and assessing the structure of the vessel [2], which is extremely important in the context of cardiovascular diseases.

The uniqueness of ultrasound is based on the fact that different layers of the coronary artery wall reflect ultrasound waves differently, anatomically preconditioned. Therefore, understanding the anatomical aspect of the vessel structure is the key to interpreting the intracoronary images. Even though IVUS is widely used in the leading clinics [3], for the majority, it is a less accessible procedure [4]. Unfortunately, IVUS remains an innovative procedure for much medical staff and requires further explanation of coronary vessel morphology.

The coronary artery size is variable and impacts the coronary stent implantation and optimization of the results of coronary revascularization [5, 6]. To our knowledge, there is no data on the size of coronary arteries ostia among the Ukrainian population using IVUS.

THE AIM

To perform a morphometric and morphological assessment of the coronary arteries ostia by intravascular ultrasound among the Ukrainian population.

MATERIALS AND METHODS

Study design and patient selection. Patients from the Lviv Regional Clinical Hospital and the Ukrainian-Polish Heart Center «Lviv» (Lviv, Ukraine) were involved in the study. Inclusion criteria: patients who underwent IVUS of the right coronary artery (RCA) or left coronary artery (LCA) before percutaneous interventions; informed consent of the patients/legal guardians on collecting the clinical data and samples, according to the Decla-

ration of Helsinki. Exclusion criteria: patients after the coronary artery bypass grafting, hemodynamically unstable patients, and patients who underwent IVUS of the branches of the coronary arteries without assessment of the coronary artery ostia. The Local Bioethics Commission approved the study.

IVUS images of 25 patients with the following gender distribution were obtained: 15 men and 10 women. The patient's selection was based on the Guideline for percutaneous coronary intervention according to the American College of Cardiology Foundation, the American Heart Association, and the Society for Cardiovascular Angiography and Interventions [7]. In 13 cases, the indication for IVUS was angiographically indeterminate left main CAD (Class IIa, Level of Evidence: B). In 8 cases, the indication for IVUS was non-stem lesion of the left coronary artery with angiographically intermediate stenosis (50-70% stenosis) (Class IIb, Level of Evidence: B). In this research, it was the lesion of the right coronary artery. IVUS was performed without any complications.

The assessment was performed on an angiograph Siemens Artis Zee Floor Eco (Munich, Germany) and IVUS Philips Volcano (Brussels, Belgium). Access through the radial artery under local anaesthesia with 2% lidocaine solution (Lekhim-Kharkiv, Kharkiv, Ukraine). The introducer Radiofocus Terumo (Fujinomiya, Japan) was introduced along with the conductor, followed by heparin (Novopharm-Biosynthesis, Novograd-Volynskyi, Ukraine). Coronary angiography was performed with an Impulse Boston Scientific diagnostic catheter (Boston, USA). Intravascular imaging was performed using the conduction-directing catheter Launcher Medtronic (Dublin, Ireland). BMU Universal II Abbott (Abbott Park, Illinois, USA) conductor was placed in the respective segment of the coronary vessel. Intravascular ultrasound was performed using the catheter Volcano Eagle Eye Platinum Philips (Brussels, Belgium). The contrast material was Ultravist 470 (Bayer, Germany). We used the cross-sections of the coronary ostia to automatically measure the minimum diameter, mean diameter, maximum diameter and lumen area (LA), which means the media-to-media dimension of the coronary artery. Image analysis was performed using the corresponding software on an IVUS Philips Volcano (Brussels, Belgium). The results of the examination were reviewed separately by two independent interventional cardiologists.

We performed statistical analysis using R version 4.0.5 software (R Core Team, 2021). Student's t-test was used to compare average values. A value of $p<0.05$ was considered to be statistically significant. Data is presented in M±SD.

RESULTS

A total of 25 IVUS examinations were collected from patients of both sexes and the same ages: 61,27±10,24 for males and females 68±5,83 (p=0.64). The left coronary artery ostium assessment was performed in 13 (52%) cases: 8 men and 5 women (32% and 20%, respectively). The right coronary artery ostium assessment was performed in 12 (48%) cases: 7 men and 5 women (28% and 20%, respectively).

There is a statistically significant difference between men and women in the minimum diameter, mean diameter, maximum diameter, and lumen area. All morphometric parameters are significantly higher in men. Clinical characteristics of patients and differences between the morphometric parameters in the male and female groups are shown in Table I.

In men, the maximal diameter of the RCA was higher than in the LCA (6.4±0.40mm and 5.56±0.60mm, respectively). The same differences were found in the mean diameter and lumen area ($p<0.05$). In women, the minimum diameter, mean diameter, maximum diameter and lumen area of the RCA were higher than LCA but without statistically significant differences. Morphometric parameters of the left and right coronary arteries in men and women are presented in Table II (Fig. 1).

Intergroup comparison of the LCA showed statistically significantly higher parameters in maximal diameter (p=0.003) and mean diameter (p=0.03) in men than in women. In addition, all morphometric parameters of the RCA in men were higher than in women ($p<0.001$)

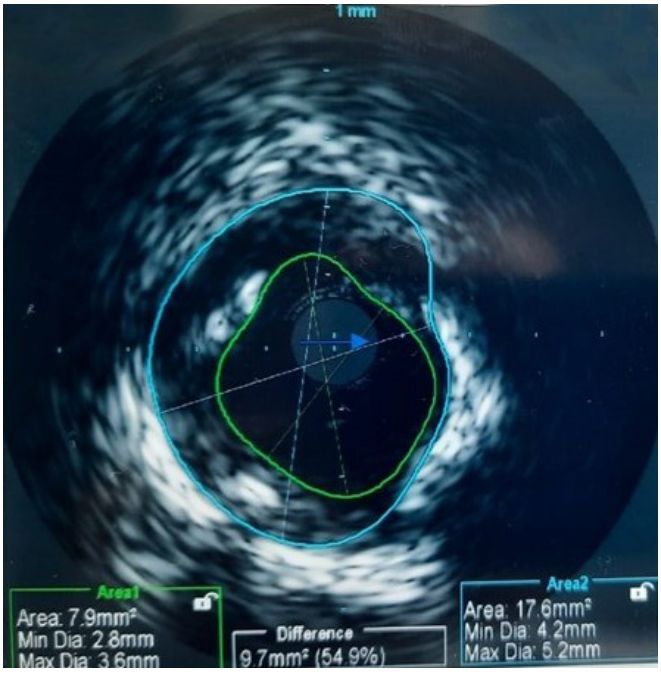

Fig. 1. An IVUS image of the right coronary ostium demonstrates a minimal lumen area (green circle) and lumen area (blue circle) of 17.6 mm2 with a minimal diameter 4.2 mm and a maximal diameter 5.2 mm.

Table I. Clinical characteristics of the patients who underwent IVUS. Values are presented in mean ± standard deviation

Parameters	Males (n=15)	Females (n=10)	p
Age (years)	61,27±10,24	68±5,83	0.64
Height (cm)	1,73±0.05	1,61±30	0.0001
Weight (kg)	84.33±9.62	79,73±13,33	0.008
Body mass index (kg/m^2)	28,25±2.90	30,96±6,53	0.38
Lumen area, mm^2	23.16±6.03	17.31±2.12	0.002*
Minimal diameter, mm	4.79±0.92	4.02±0.4	0.010*
Maximal diameter, mm	5.95±0.66	4.82±0.34	0.00001*
Mean diameter, mm	5.37±0.74	4.41±0.33	0.0002*

*P-value of <0.05 was considered significant

Table II. Morphometric parameters of the left coronary artery (LCA) and right coronary artery (RCA) in men and women. Values are presented in mean ± standard deviation

Parameters	LCA	RCA	p (t) (LCA:RCA)
	M±SD	M±SD	M±SD
	Male patients		
Lumen area, mm^2	20.43±6.92	26.29±2.74	0.043*
Minimal diameter, mm	4.56±1.16	5.04±0.48	0.30
Maximal diameter, mm	5.56±0.6	6.4±0.4	0.005*
Mean diameter, mm	5.06±0.86	5.72±0.4	0.067*
	Female patients		
Lumen area, mm^2	16.35±2.51	18.28±1.2	0.17
Minimal diameter, mm	3.84±0.51	4.2±0.12	0.18
Maximal diameter, mm	4.7±0.25	4.94±0.4	0.30
Mean diameter, mm	4.25±0.33	4.57±0.25	0.14

*P-value of <0.05 was considered significant

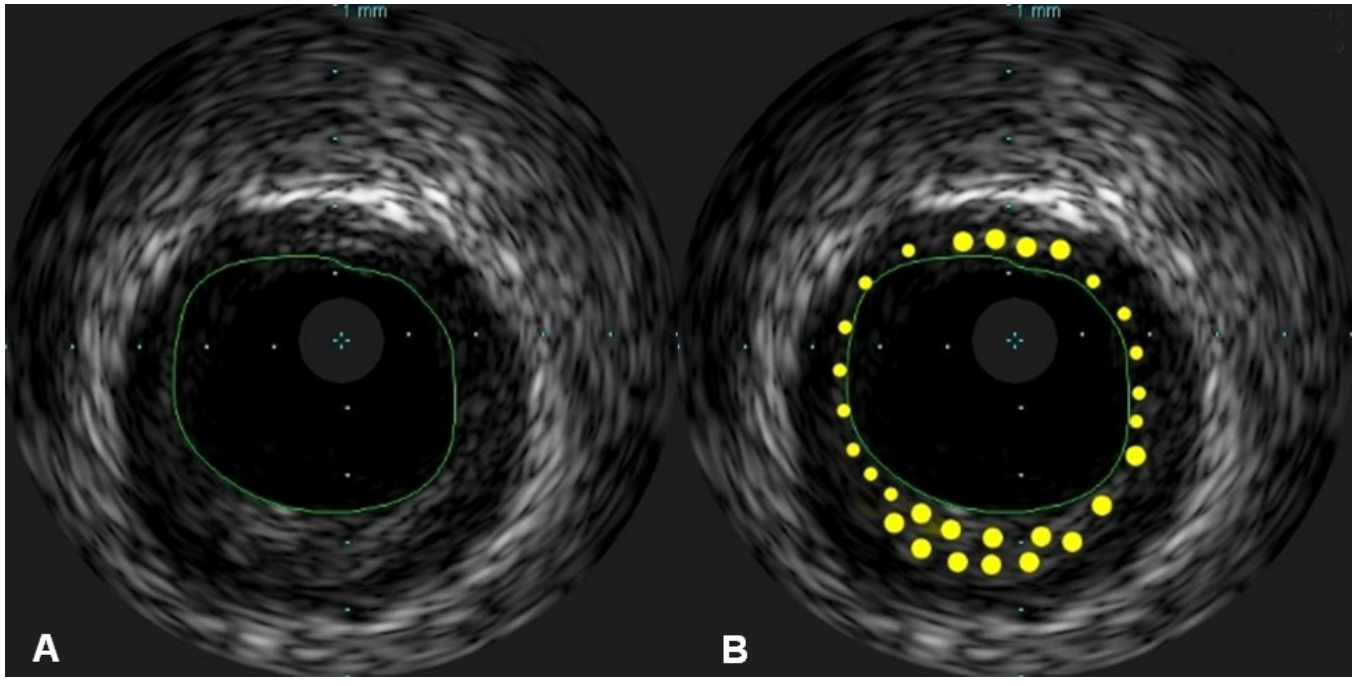

Fig. 2. (A) An IVUS image of the coronary ostium. The grey circle in the middle points to the location of the ultrasound imaging catheter. The lumen is shown as a dark area (green circle). (B) Corresponding intravascular ultrasound image of the coronary artery with depicted intima (yellow circle).

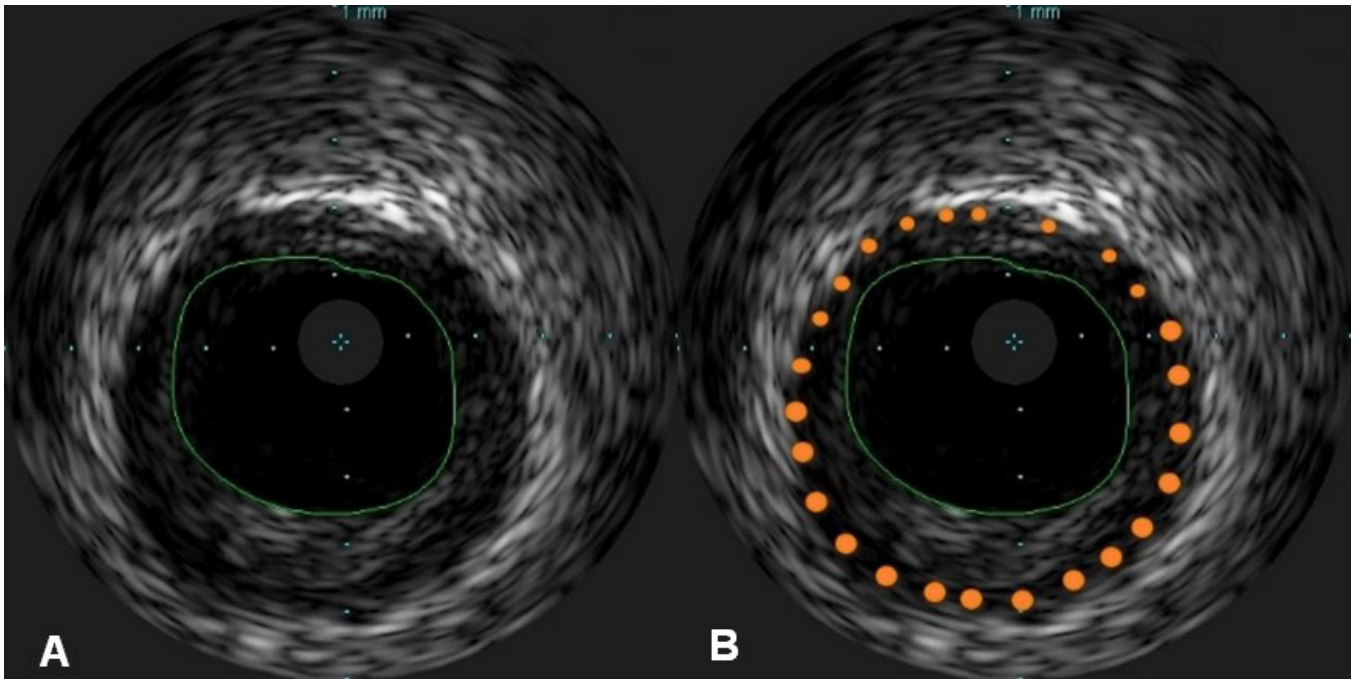

Fig. 3. (A) An IVUS image of the coronary ostium. The grey circle in the middle points a location of ultrasound imaging catheter. The lumen is showed as a dark area (green circle). (B) Corresponding intravascular ultrasound image of coronary artery with depicted media (orange circle).

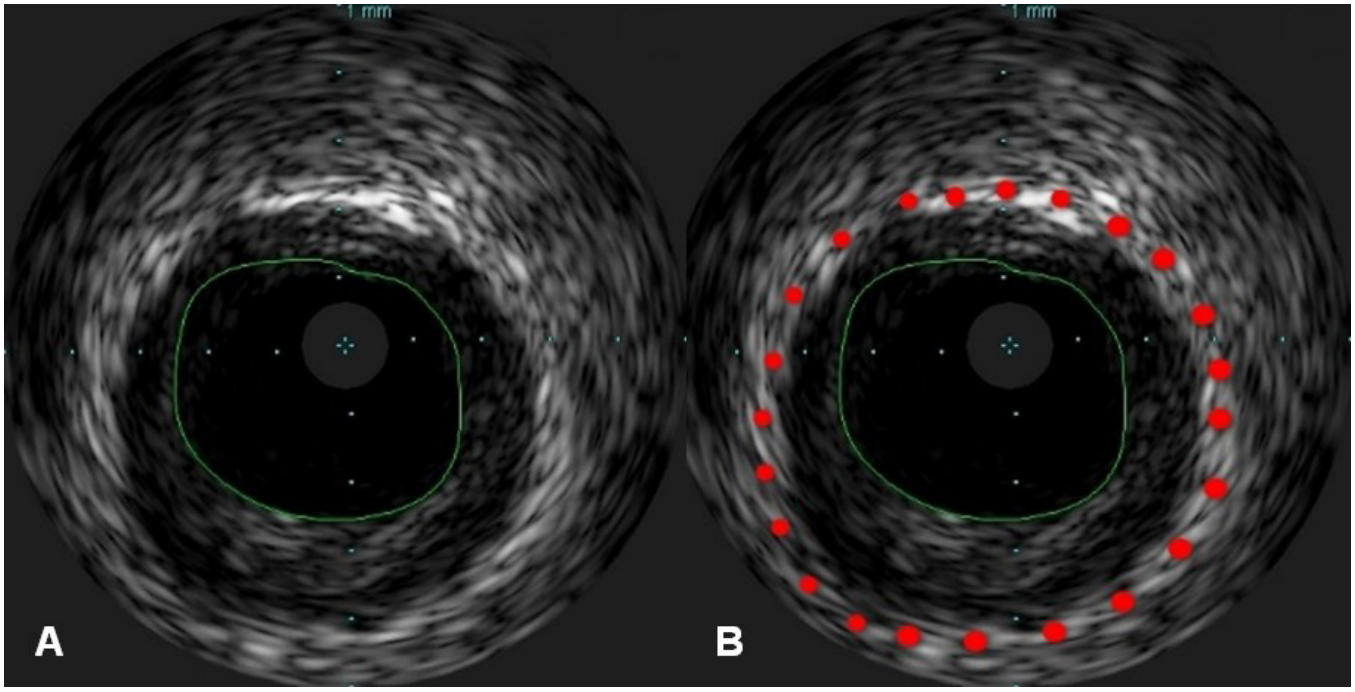

Fig. 4. (A) An IVUS image of the coronary ostium. The grey circle in the middle points to the location of the ultrasound imaging catheter. The lumen is shown as a dark area (green circle). (B) Corresponding intravascular ultrasound image of the coronary artery with depicted adventitia (red circle).

Morphological evaluation of the intravascular imaging showed that the intima reflects ultrasound waves producing a uniform concentric echo, which is visualized in the form of a light ring. The reason is the parallel location of the endotheliocytes to the lumenal edge of the vessel (Fig. 2). Even though the coronary arteries are vessels of elastic type, the media contains a significant number of smooth myocytes, which do not reflect ultrasound waves. Thus, ultrasound waves pass through the media and have a dark colour in the image. It allows us to distinguish the media easily (Fig. 3). The longitudinal orientation of the fibers in adventitia contributes to the intense reflection of ultrasound waves and a bright stripe on the image (Fig. 4). It also occurs in the case of atherosclerotic plaques calcification (Fig. 5). The adventitia, unlike intima, does not have the form of a concentric ring. Anatomically, it is due to the ability of the

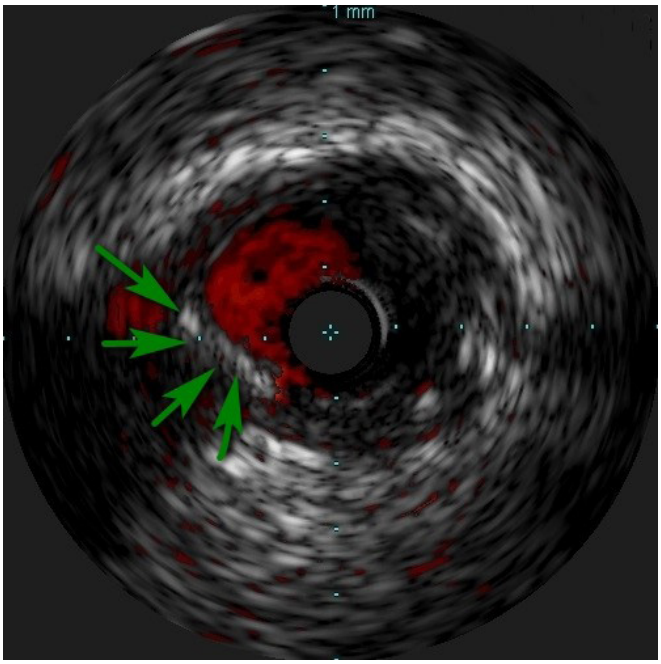

Fig. 5. An IVUS image of the coronary ostium shows an atherosclerotic plaque with calcification (green arrows) and acoustic shadowing.

adventitia to affect the diameter of the coronary artery due to the parallel orientation of the collagen fibers and the loose consistency of connective tissue.

DISCUSSION

he current study shows that coronary artery ostia diameters and luminal areas assessed by intravascular ultrasound were significantly higher in men than in women among the Ukrainian population. Overall, in men, the maximal diameter, the mean diameter and the lumen area of the RCA were higher than in the LCA. In contrast, we did not prove the differences between all morphometric parameters of RCA and LCA in women. In addition, this study found higher all morphometric parameters of the RCA in men than in women, but only the maximal and mean diameter of the LCA. Finally, this study allowed the performing of a morphological evaluation of the coronary artery ostia.

Taking into account that the proximal segments of the coronary arteries are affected in most cases [8], we analyzed the coronary ostia. The diameter of the vessel's lumen correlates with the development of major cardiac events [1, 9]. The data obtained are consonant with the statements made by other authors that coronary artery diameter is higher in men than in women [9-10]. Despite previous studies showing larger diameters of the LCA [3, 9, 10], our results showed higher parameters of the RCA. It could be explained by different factors, from clinical parameters of selected patients to assessing tools and modalities. There are no consolidated registries or publications of coronary ostia diameters among the Ukrainian population assessed by IVUS, which makes this research valuable in further investigations.

The limited availability of IVUS [3] prompted us to add a morphological evaluation. In the presented study, the observed changes in echogenicity are explained by the anatomic precondition. In our opinion, understanding the morphological aspect of the vessel structure is crucial in interpreting intracoronary images. Moreover, it helps to explicate conditions that contribute to the morphological changes of the vascular wall [2, 3, 11].

The provided study has limitations. It was a single-centre, retrospective study. The small sample size was due to the precise guidelines for IVUS use, given several aspects of the availability of IVUS [3, 7]. IVUS is like new technology in Ukraine, which might impact the use frequency. In addition, further research would be welcomed to increase the sample size to generalize the results.

CONCLUSIONS

We conclude that IVUS analysis shows significantly higher parameters of the minimum diameter, mean diameter, maximum diameter and lumen area in men than women in the Ukrainian population. The difference in parameters of the right coronary artery and the left coronary artery varies between gender groups.

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Conflict of interest:
The Authors declare no conflict of interest.

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