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ARTYKUŁ ORYGINALNY / *ORIGINAL ARTICLE*

Percutaneous recanalisation of chronically occluded coronary arteries with the CrossBoss/Stingray system: first experience (report of three cases)

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Abstract

Background and aim: Percutaneous coronary interventions (PCI) within chronically occluded coronary arteries remain challenging procedures with a lower success rate compared to classic PCI. However, over the last years we have witnessed many technological advances in the treatment of chronic total occlusion (CTO) including new wires, retrograde approach, subintimal tracking and re-entry technique, all underlying which the current success rate of up to 95% in dedicated centres. Subintimal space wire penetration is no longer a problem that would require terminating the procedure. It is now a desired part of hybrid CTO approach involving both antegrade and retrograde crossing and re-entry. The new device which facilitates controlled dissection and true lumen re-entry is the Boston Scientific Coronary CTO Crossing System consisting of a CrossBoss microcatheter and Stingray balloon and dedicated wire.

Methods: On October 29th and 30th, 2014, percutaneous coronary recanalisation using the CrossBoss/Stingray system was performed in 3 men aged 63–75, with symptoms of stable CCS class II/III angina, without prior myocardial infarction in the area of CTO artery supply and with preserved myocardial contractility. Each patient underwent at least one previous unsuccesful antegrade/retrograde CTO recanalisation procedure. The J-CTO score was 3–4.

Results: The procedure was successful in all 3 patients: 2 right coronary arteries and 1 left anterior descending artery were opened. In all 3 cases, both the CrossBoss catheter and the Stingray re-entry system were used. Two to three drug eluting stents were implanted in each patient, with the total length of 62–106 mm and final TIMI 3 flow. The mean procedure time was 141 min (130–150 min), mean fluoroscopy time was 53 min (48–56 min), absorbed dose was 4772 mGy (4098–5633 mGy), dose area product was 565,208 cGy × cm^2 (535,109–590,266 cGy × cm^2), and the mean contrast volume was 343 mL (320–350 mL). No procedure-related complications were note except for an asymptomatic increase in high-sensitivity troponin T level up to 157 ng/mL (reference range 0–14 ng/mL) in 1 patient.

Conclusions: The Boston Scientific Coronary CTO Crossing System is a useful device for percutaneous recanalisation of chronically occluded coronary arteries. It helps to achieve procedural success in more complex cases within relatively short crossing times and with a limited amount of the contrast agent and X-ray dose.

Key words: percutaneous coronary intervention, chronic total occlusion, CrossBoss, Stingray

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INTRODUCTION

Chronic total occlusion (CTO) of a coronary artery is defined as a total vessel closure with Thrombolysis In Myocardial Infarction (TIMI) flow lasting for at least 3 months. The true incidence of CTO in the general population is not known due to a large proportion of asymptomatic or oligosymptomatic cases. In angiographic studies CTO is found in 20–40% of patients with established coronary artery disease [1–4]. For many years, CTO was a major indication for surgical myocardial revascularisation or continued medical therapy. Percutaneous coronary intervention (PCI) was considered a difficult, lengthy, and costly procedure, and its success rate was 50–70%. With major advances in medical technology that took place in the recent years, experienced centres now undertake PCI of CTO quite willingly, and the success rate is up to 95% [5, 6]. These advances include 3 major improvements, namely development of an ever-growing family of dedicated guidewires, introduction of the technique of retrograde recanalisation using collateral circulation vessels, and introduction of the dissection and reentry technique [7, 8]. The current approach to CTO recanalisation involves hybrid procedures that use all the above techniques based on vessel anatomy and the course of the procedure itself [9].

The classical anterior dissection and reentry technique uses guidewires covered with a layer of hydrophilic polymer (e.g., Fielder XT, XTA, Asahi Intecc, Japan; Pilot family, Abbott Vascular, USA) to create subintimal space dissection. The knuckle at the end of the guidewire, formed spontaneously or created manually, is advanced within subintimal space and bypasses the occlusion site. The size of the knuckle is controlled by a microcatheter which is introduced behind it. Although apparently brutal, the procedure is safe and effective, with perforation reported only occasionally. However, reentry to the true vessel lumen may be challenging. Currently being abandoned subintimal tracking and re-entry (STAR) [7] and miniSTAR [10] techniques may be used for this purpose, based on blunt, random perforation of the vascular endothelium with the guidewire knuckle. Another approach involves endothelial puncture using a stiff angioplasty guidewire (e.g., Confianza, Asahi Intecc, Japan), so called limited antegrade subintimal tracking technique [11], but its effectiveness is limited. The controlled antegrade and retrograde tracking and dissection (CART) and reverse CART (rCART) techniques are based on antegrade and retrograde dissection and joining these two subintimal spaces by balloon inflation at the occlusion level. A prerequisite of such procedures is the presence of interventional collaterals.

A new approach for advancing a guidewire through an occluded coronary segment involves use of the Boston Scientific Coronary CTO Crossing System. On October 29–30, 2014, 3 CTO recanalisation procedures using this system were performed in our cardiac catheterisation laboratory.

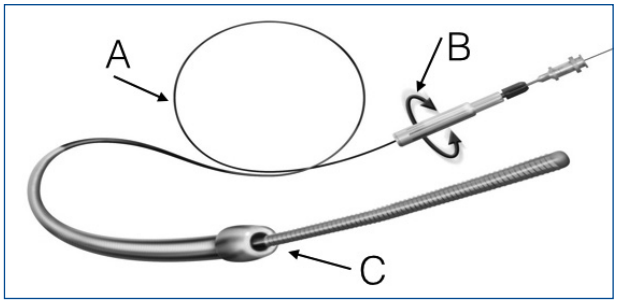

Figure 1. CrossBoss; A — a catheter compatible with a 6 F guiding catheter and an 0.014 inch guidewire; B — a dedicated torquer for "fast-spin" rotation; C — an atraumatic 1 mm tip (courtesy of Boston Scientific)

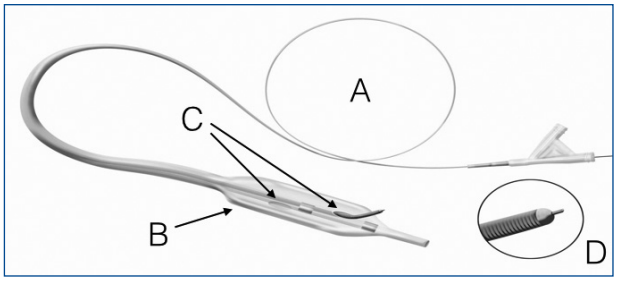

Figure 2. Stingray, A — a delivery over-the-wire system compatible with an 0.014 inch guidewire; B — a flat balloon that wraps around the vessel lumen in the subintimal space; C — two openings for the guidewire, located at the opposite surfaces and ends of the balloon and marked with two metallic markers; D — Stingray guidewire tip (courtesy of Boston Scientific)

METHODS

Design

Boston Scientific Coronary CTO Crossing System (previously known as BridgePoint Medical System) was introduced in 2008. It consists of three components: the CrossBoss catheter, the Stingray balloon, and the Stingray guidewire. These components may be used independently from each other.

The CrossBoss catheter (Fig. 1), made from stainless steel, is of the over-the-wire (OTW) design and uses a 0.36 mm (0.014 inch) guidewire. Its length is 135 cm, and the diameter is 1.13 mm (3.4 F) proximally and 0.79 mm (2.4 F) distally. It has an olive tip of 1.0 mm (3.0 F) diameter and length. Minimum guidewire diameter is 6 F. The purpose of the CrossBoss catheter is to create a longitudinal coronary artery dissection in parallel to the occluded segment. In one third of cases, the catheter returns spontaneously to the distal true lumen. In contrast to dissection created by a knuckled angioplasty guidewire, dissection by the CrossBoss catheter is controlled, i.e. has a small diameter and its length is planned by the operator.

The Stingray balloon catheter (Fig. 2) is also of OTW design, with the length of 135 cm and the diameter of

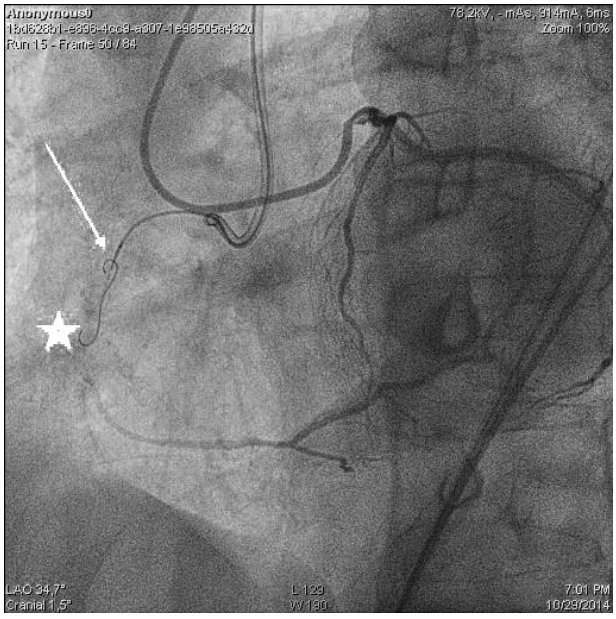

Figure 3. A knuckle (*) formed with a Fielder XT guidewire (Asahi Intecc, Japan) in the subintimal space of the right coronary artery. An arrow indicates the tip of the microcatheter

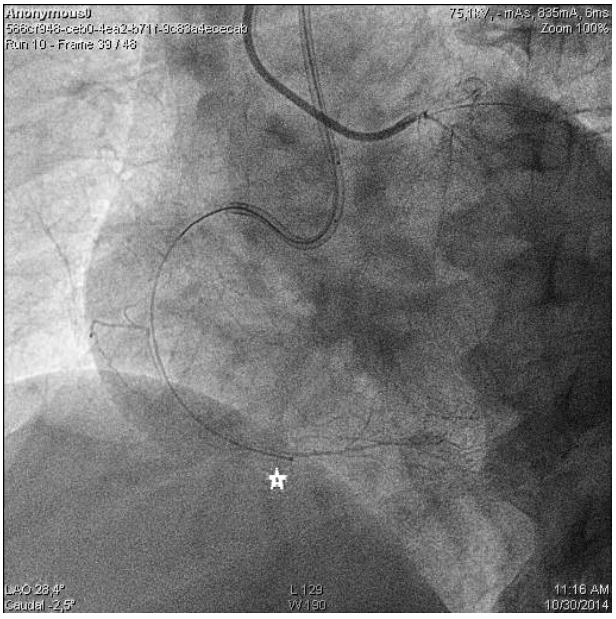

Figure 4. A CrossBoss catheter introduced in parallel to the true lumen of a coronary artery. The tip of the catheter (*) is located in a wide and well visualised distal segment of the vessel

1.22 mm (3.7 F) proximally and 0.97 mm (2.9 F) distally. Its name comes from the flat shape of the balloon, resembling the Atlantic stingray fish. This balloon shape allows, after filling with the contrast agent, its semicircular wrapping around the vessel. Balloon length is 10 mm, its width when inflated is 2.5 mm, and its thickness is 1 mm. The balloon has 3 openings, 1 distal for the angioplasty guidewire and 2 side openings at the opposite surfaces and ends of the balloon. Both side openings have metallic markers and serve as exit ports for the Stingray guidewire.

The Stingray guidewire (Fig. 2) is dedicated for reentry. Its diameter is 0.36 mm (0.014 inch) and its length is 300 cm or 185 cm. Its distal 20 cm segment with the diameter of 0.25 mm (0.010 inch) is radiopaque and covered with a hydrophilic layer. The distal 1.5 mm is bent at 28 degrees and equipped with a 0.18 mm (0.007 inch) long and 0.09 mm (0.0035 inch) wide probe for vessel wall puncture.

Procedure

The CrossBoss catheter may be inserted directly into a soft, tapered lesion. In most cases, however, the proximal plaque cap must be crossed before advancing the catheter. This can be accomplished by various techniques, typically using a dedicated CTO angioplasty guidewire. These guidewires are usually polymer-coated, tapered, soft (e.g., Fielder XT, Fielder XTA, Asahi Intecc, Japan) or hard (e.g., Pilot 200, Abbott Vascular, USA). If the lesion is very hard, calcified, or bluntly terminated, a high entry force guidewire should be used (e.g., Confianza Pro 12, Asahi Intecc, Japan; Progress 200T, Abbott Vascular, USA). A special algorithm has been developed, allowing guidewire choice based on CTO morphology, but this is beyond the scope of the current report. Microcatheters (e.g., Corsair, Asahi Intecc, Japan; Finecross, Terumo, Japan) are used to support the guidewire and control its advancement. After advancing the guidewire for initial few millimetres of the occlusion or crossing a highly calcified segment, it is again replaced with a Fielder XT or Pilot 200 guidewire with a knuckled tip (Fig. 3). Gradual advancement of the guidewire results in blunt vessel dissection. Creation of the latter serves two purposes: 1) its characteristic course as seen under fluoroscopy confirms location of the guidewire within the vessel wall; and 2) a wide entry into the dissection channel facilitates introduction of the CrossBoss catheter. As the latter is of the OTW design, its introduction requires use of a 280- to 300-cm long guidewire, guidewire extension, or trapping a shorter 180 cm guidewire within the catheter using a balloon. However, this requires use of an at least 7 F catheter. When the CrossBoss catheter is advanced to the tip of the guidewire, the latter is withdrawn, and the CrossBoss catheter is rapidly rotated manually ("fast spin") using a special torquer mounted on the catheter. This rotation may proceed in both directions, allowing catheter advancement which is usually rapid, with its range controlled by the position of the torquer on the catheter. Proper catheter position should be verified by retrograde contrast agent injections to a contralateral vessel (Fig. 4). Contrast agent injections to the occluded vessel should be avoided so as to avoid undue progression of the dissection. The channel created by the CrossBoss catheter

should reach below the occluded segment, reentering the vessel within its straight segment at a safe distance (at least several millimetres) away from any significant side branches. If the CrossBoss catheter is advanced into a side branch, it may be repositioned into the main vessel using the knuckle or a stiff guidewire. If growing intramural hematoma is suspected, which may be evidenced by collapsing distal vessel lumen, the CrossBoss catheter may be used for aspirating blood with a large Luer Lock-type syringe. After the CrossBoss catheter is fully advanced, a hard-tip guidewire (usually Miraclebros 6, Asahi Intecc, Japan) is inserted into it. The tip of the guidewire should be placed at the olive tip of the CrossBoss catheter.

Exchange of the CrossBoss catheter for the Stingray balloon catheter should occur swiftly in the conventional way, as with any OTW catheters. Before introduction, the balloon should be carefully bled from air and connected to an inflator filled with 100% contrast agent. After the balloon is appropriately positioned, it should be slowly filled to 3–4 bar pressure. Appropriate balloon placement is confirmed by a parallel position of the vessel lumen filled retrogradely with the contrast agent and the balloon axis with 2 markers in line (Fig. 5).

The next stage is introduction of the Stingray guidewire into the balloon catheter. Manual manoeuvering with its bended tip allows easy selection of 1 of the 3 exit ports. Vessel wall puncture and entry to the true lumen should be performed by the port directed towards the latter, by a forceful guidewire push for several millimetres (Fig. 5). The guidewire may be then inserted deeper in the vessel but its stiffness often precludes effective manoeuvering. Thus, a "stick-and-swap" technique became popular, involving an exchange of the Stingray guidewire for a different working one (e.g., Pilot 200, Abbott Vascular, USA, or Sion Blue, Asahi Intecc, Japan). The stable position of the Stingray balloon allows safe guidewire exchanges without losing the entry to the true lumen. Vessel wall puncture may be attempted repeatedly in case of its failure or difficulties with guidewire exchange. The Stingray catheter may be also moved along the vessel to attempt true lumen reentry in another segment (bobsled technique).

All components of the system may be repeatedly used during the procedure.

Further stages of the procedure are similar to conventional coronary angioplasty, with predilatation followed by stent implantation to cover the whole dissected segment.

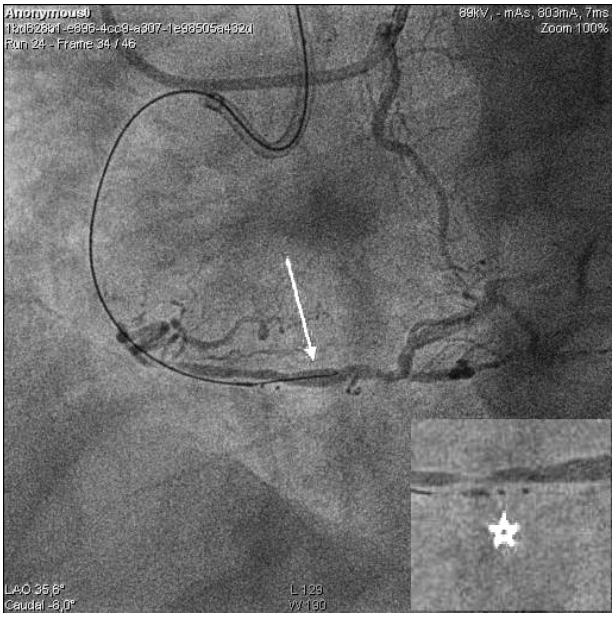

Figure 5. Confirmation of the presence of a Stingray guidewire (arrow) in the vessel lumen by retrograde injection of a contrast agent to the left coronary artery. An asterisk indicates two markers of the Stingray balloon catheter

Case descriptions

Patient number 1. The patient was a 64-year-old man with stable Canadian Cardiovascular Society (CCS) class II angina, a history of anterior wall myocardial infarction in 2011, hypertension, hypercholesterolaemia, previous smoking, mild aortic stenosis (maximum pressure gradient 26 mm Hg), and left ventricular ejection fraction (LVEF) of 45% and anterior wall hypokinesis by echocardiography (Table 1). Coronary angiography in 2014 showed a critical stenosis of the left anterior descending artery (LAD) and an occlusion of the right coronary artery (RCA) in its middle segment (Fig. 6). Successful LAD angioplasty with implantation of a drug-eluting stent (DES) was performed. An attempt to recanalise RCA was unsuccessful — the occluded segment was crossed but the angioplasty guidewire could not be returned from the dissection channel to the true vessel lumen.

Numerous small bridge collaterals were present at the site of CTO, the length of the occlusion was estimated by quantitative coronary angiography (QCA) at 35 mm, and calcifications were not seen. Septal collaterals from LAD and epicardial collaterals from the left circumflex artery (LCx) were very narrow and tortuous. The Multicenter CTO Registry of Japan (J-CTO) score was 3 (Table 2). Recanalisation was performed by bilateral femoral artery cannulation with 8 F guiding catheters. The proximal segment of the occlusion was crossed with a Fielder XT guidewire and a Corsair microcatheter. The same guidewire was used to form a knuckle which was replaced with a CrossBoss catheter. The latter was introduced to the distal RCA segment where it was exchanged for a balloon Stingray catheter using a Miraclebros 6 guidewire. A Stingray guidewire was used for a single puncture and then was replaced for a Sion guidewire which was advanced distally. This was followed with balloon predilatation and implantation of 3 DES with the total length of 95 mm, resulting in TIMI 3 flow (Fig. 7, Table 3). No procedural complications were observed (Table 4).

Patient number 2. The patient was a 63-year-old man with stable CCS class III angina, a history of hypertension,

Table 1. Demographic and clinical data of patients undergoing recanalisation procedures

	Patient		
	Number 1	Number 2	Number 3
Gender	Male	Male	Male
Age [years]	64	63	75
Symptoms	CCS class II	CCS class III	CCS class II
Previous MI in CTO area	No	No	No
Presence of Q wave in CTO area	No	No	No
Contractility of CTO area by echocardiography	Normokinesis	Normokinesis	Normokinesis
LVEF [%]	45	63	55
Previous MI in other area	Anterior wall (2011)	No	No
Previous PCI attempt	2014, antegrade	1998, 2014, antegrade	2013, 2014, antegrade + retrograde
Reason for unsuccessful PCI of CTO	Unsuccessful re-entry	Unsuccessful re-entry	Unsuccessful penetration, perforation
Hypertension	Yes	Yes	Yes
Hyperlipidaemia	Yes	Yes	No
Diabetes	No	No	No
Smoking	Previous	Previous	No
Obesity	No	No	No
Family history	No	No	No
Other	Mild aortic stenosis	No	Left-sided nephrectomy

CCS — Canadian Cardiovascular Society; CTO — chronic total occlusion; LVEF — left ventricular ejection fraction; MI — myocardial infarction; PCI — percutaneous coronary intervention

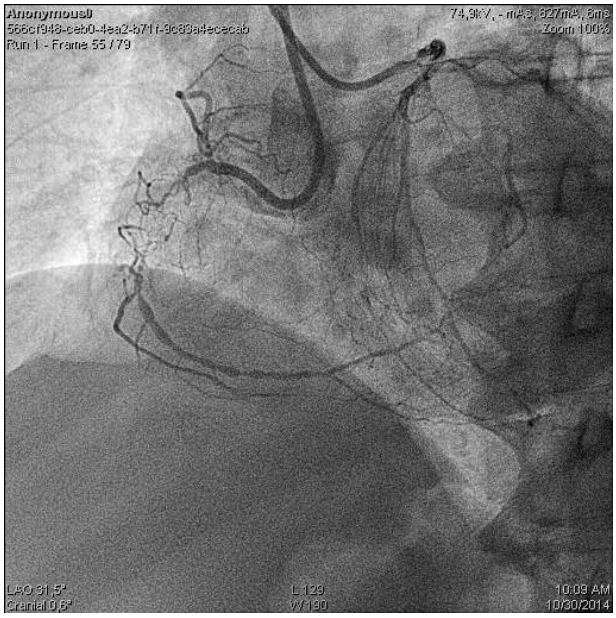

Figure 6. Patient number 1 — occlusion of the right coronary artery

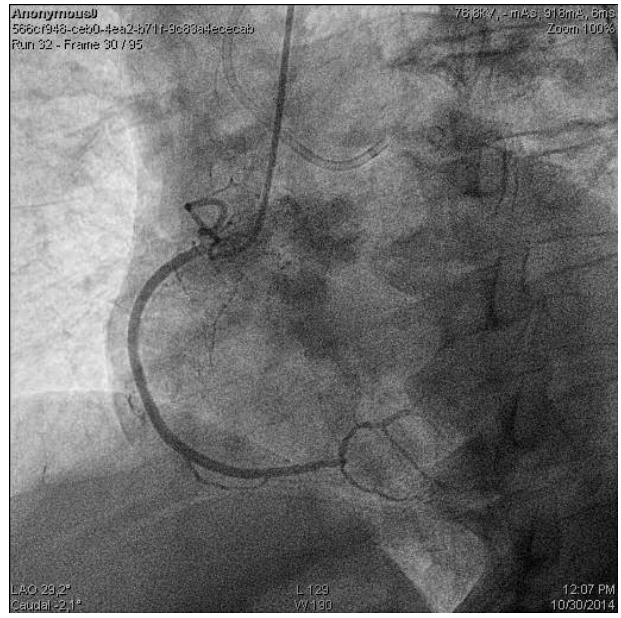

Figure 7. Patient number 1 — final effect of the percutaneous coronary intervention in the right coronary artery

hypercholesterolaemia, previous smoking, and LVEF of 63% with normal wall motion preserved in all segments by echocardiography (Table 1). Coronary angiography in 1994 showed a critical LCx stenosis and an occlusion of the middle LAD segment. At that time, successful LCx angioplasty with implantation of a bare metal stent was performed. An attempt of LAD recanalisation failed, resulting in extensive dissection at the origin of the diagonal branch. Coronary angiography

Table 2. Angiographic data of patients undergoing recanalisation procedures

	Patient		
	Number 1	Number 2	Number 3
Treated artery	RCA	LAD	RCA
Dominant artery	RCA	RCA	RCA
Occluded segment	2	7	1+2
Other lesions	DES in LAD	BMS in LCx	No
Collaterals	Noninvasive	Noninvasive	Invasive (from LCx)
Proximal occlusion	Blunt	Blunt	Blunt
Calcifications	No	Yes	No
Tortuosity over 45°	No	No	No
Occlusion length over 20 mm	Yes	Yes	Yes
Previous PCI attempt	Yes	Yes	Yes
J-CTO score	3	4	3

BMS — bare metal stent; DES — drug-eluting stent; J-CTO — Multicenter CTO Registry of Japan; LAD — left anterior descending artery; LCx — left circumflex artery; PCI — percutaneous coronary intervention; RCA — right coronary artery

Table 3. Equipment and radiation doses during recanalisation procedures

	Patient		
	Number 1	Number 2	Number 3
Femoral access	8 F + 8 F	8 F + 8 F	8 F + 8 F
Guidewire for penetration	Fielder XT	Pilot 200	Progress 200T
Microcatheter	Corsair	Corsair	Corsair
Knuckle guidewire	Fielder XT	Pilot 200	Pilot 200
Guidewire for exchanging CrossBoss for Stingray	Miraclebros 6	Miraclebros 6	Miraclebros 6
Reentry guidewire	Sion	Sion	Pilot 200
Number of guidewires used	6	7	8
Number of implanted drug-eluting stent	3	2	3
Length of implanted stents [mm]	95	62	106
Duration of procedure [min]	145	150	130
Fluoroscopy time [min]	56	48	56
Absorbed dose [mGy]	4586	4098	5633
Dose area product [cGy × cm^2]	570,251	535,109	590,266
Amount of contrast agent [mL]	320	360	350

Table 4. Biochemical testing before and after recanalisation

	Patient		
	Number 1	Number 2	Number 3
Peak hsTnT (reference range 0–14 ng/mL)	29	42	157
Peak CK-MB (reference range 0–5 IU/L)	5	3.5	19
eGFR before (mL/min/1.73 m^2)	93	78	72
eGFR after (mL/min/1.73 m^2)	116	102	73

CK-MB — creatine kinase isoenzyme MB; eGFR — estimated glomerular filtration rate; hs-TnT — high sensitity troponin T

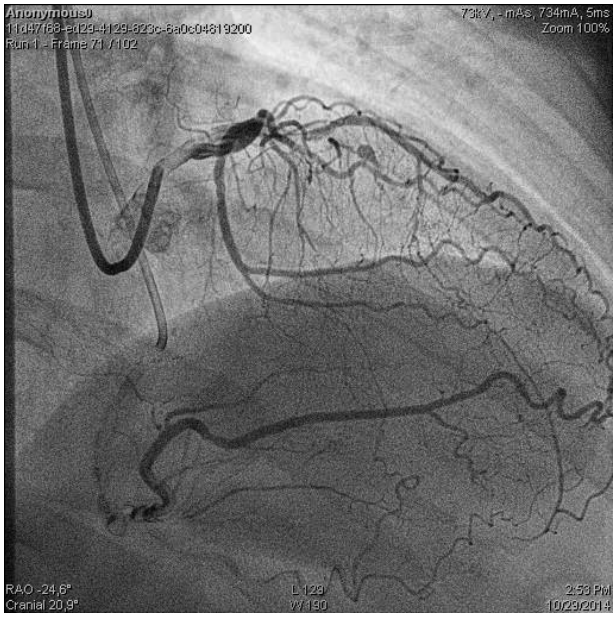

Figure 8. Patient number 2 — occlusion of the middle segment of the left anterior descending artery

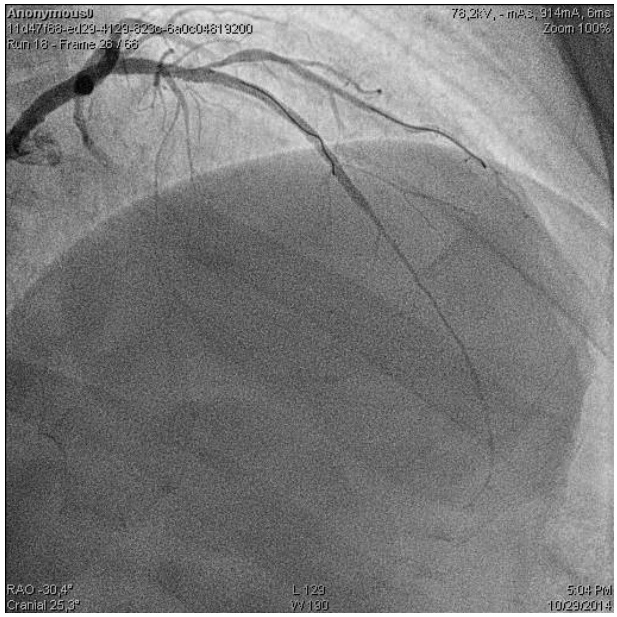

Figure 9. Patient number 2 — final effect of the percutaneous coronary intervention in the left anterior descending artery

that was performed again in October 2014 revealed a good effect of the previous LCx angioplasty and persisting LAD occlusion with a short channel of the old dissection (Fig. 8).

The occlusion was found to begin below the origin of a large diagonal branch that showed a borderline stenosis. Occlusion length by QCA was about 30 mm. Moderate calcifications were present. A narrow distal segment was supplied by a quite large but very tortuous epicardial collateral vessel originating from the posterior interventricular artery of RCA. Septal collaterals were not seen. The J-CTO score was 4 (Table 2). Recanalisation was performed by bilateral femoral artery cannulation with 8 F guiding catheters. The proximal segment of the occlusion was crossed with a Pilot 200 guidewire and a Corsair microcatheter. A CrossBoss catheter was advanced to the middle LAD segment where it was exchanged for a balloon Stingray catheter using a Miraclebros 6 guidewire. A Stingray guidewire was used for a single puncture and then was replaced for a Pilot 200 guidewire. Unfortunately, the latter could not be advanced distally, and visualisation of the peripheral circulation was lost, probably due to an intramural hematoma. A CrossBoss catheter was introduced again and moved several millimetres further. The hematoma was aspirated using the CrossBoss catheter, and another puncture with the Stingray guidewire was performed. The Stingray guidewire was then exchanged for a Sion guidewire which was advanced distally. Two DES with the total length of 63 mm were implanted following balloon predilatation, resulting in TIMI 1 flow. The distal vessel turned out to be narrow despite several intracoronary nitroglycerin injections (remodelling?). Ultimately, it was dilated using a 2 mm balloon catheter, with good angiographic effect and TIMI 3 flow (Fig. 9, Table 3). No procedural complications were observed (Table 4).

Patient number 3. The patient was a 75-year-old man with stable CCS class II angina, a history of hypertension and left-sided nephrectomy due to cancer, and LVEF of 55% with normal wall motion preserved in all segments by echocardiography (Table 1). Coronary angiography in 2013 showed a proximal RCA occlusion (Fig. 10) with a well-developed epicardial collateral vessel from LCx. Also in 2013, two unsuccessful attempts of RCA recanalisation were undertaken, both antegrade and retrograde. The first procedure was terminated after numerous failed attempts to cross the occlusion retrogradely using Fielder XT, Pilot 200, and Confianza PRO guidewires. During the second procedure, an Ellis type II perforation occurred during an attempt to cross the proximal cap using a Confianza PRO guidewire.

The conus artery originated at the site of occlusion. The length of occlusion by QCA was estimated at 30 mm, but the vessel lumen between the occlusion site and the distal vessel segment was very narrow and tortuous (a collateral vessel parallel to the true vessel?). No calcifications were present. The J-CTO score was 3 (Table 2). Recanalisation was performed by bilateral femoral artery cannulation with 8 F guiding catheters. The proximal cap was punctured using a Progress 200T guidewire. As it was not possible to advance any further guidewires, a Corsair microcatheter was wedged at the puncture site and several millilitres of a contrast agent were injected through its lumen, creating a small dissection (Carlino method). Then, the occluded segment was crossed with a Pilot 200 guidewire and a Corsair microcatheter. Due to

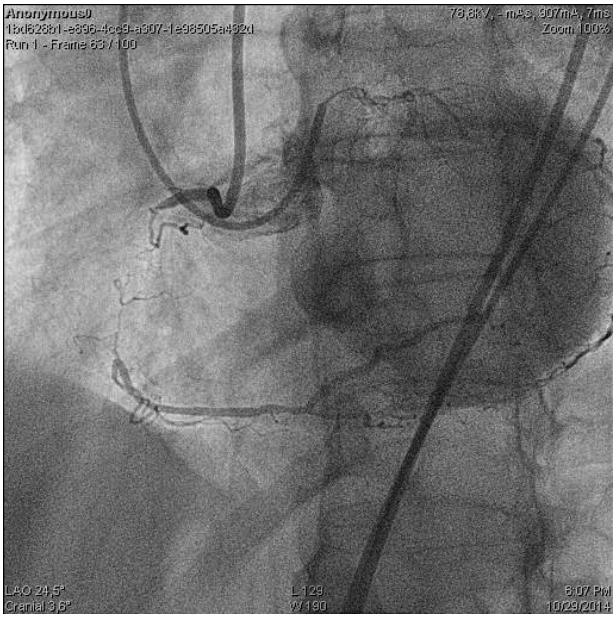

Figure 10. Patient number 3 — occlusion of the right coronary artery

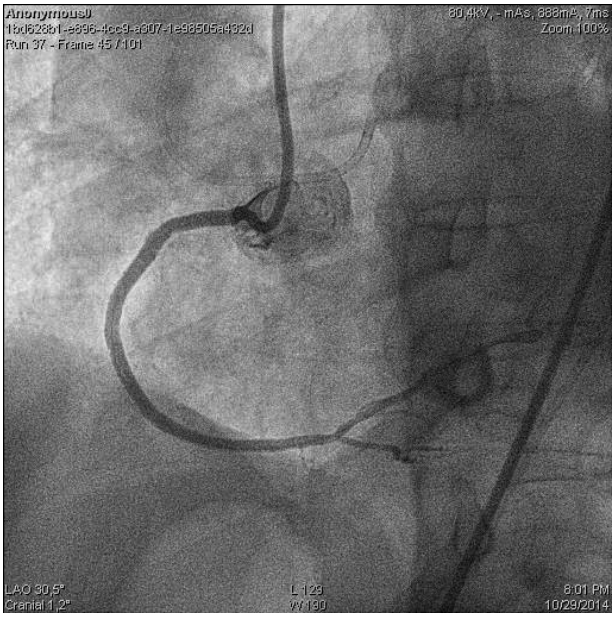

Figure 11. Patient number 3 — final effect of the percutaneous coronary intervention in the right coronary artery

difficulties with advancing a CrossBoss catheter, a predilatation of the proximal cap was performed using a 1.5 mm balloon. After the catheter entered one of the side branches, the direction of its advancement was changed by using a knuckle. The CrossBoss catheter was exchanged for a Stingray balloon catheter using a Miraclebros 6 guidewire. A Stingray guidewire was used for a single puncture and then was replaced for a Pilot 200 guidewire which was advanced distally. This was followed with balloon predilatation and implantation of 3 DES with the total length of 106 mm, resulting in TIMI 3 flow (Fig. 11, Table 3). An asymptomatic increase in cardiac marker level was observed following the procedure (Table 4).

DISCUSSION

The complexities of CTO recanalisation, extensive armamentarium used and, most importantly, long procedure duration and uncertain outcomes discourage many operators from attempting these procedures. The choice of the right technique and equipment requires many years of experience. However, CTO recanalisation procedures may be simpler and safer, and without the price of increased complication rates. The algorithm developed by Brilakis et al. [9] served as a starting point for our own procedural strategy (Fig. 12). The goal of the algorithm is to advance an angioplasty guidewire through an occluded coronary segment. This involves three major steps: crossing the proximal cap, advancing through the occluded segment, and reentry to the true vessel lumen.

The Boston Scientific Coronary CTO Crossing System is not a universal tool for recanalisation of all vessels. It was developed to facilitate 2 of the 3 steps of the recanalisation procedure: rapid and safe passage of the long occluded segment with creating an extensive dissection, and reentry from the subintimal space to the true vessel lumen precisely at the chosen site. It may also be used for crossing the proximal cup but its effectiveness is limited to soft, tapered lesions. The role of the Boston Scientific Coronary CTO Crossing System in the recanalisation algorithm results from both its advantages and limitations. Prerequisites for the use of this system include placing the catheter within the vessel wall (architecture) and the presence of a relatively disease-free distal segment where the Stingray guidewire may be used for puncture and reentry to the true vessel lumen. A limitation is poor manoeuverability of the catheter which may hamper its advancement in very tortuous vessels and result in catheter diversion into a side branch. If undiagnosed, this problem may lead to branch perforation. Major branches originating within the occluded segment may be lost after stent implantation in the subintimal space. However, they may be recovered by advancing additional guidewires through the Stingray catheter.

Experience with the Boston Scientific Coronary CTO Crossing System is relatively short, starting in 2008. First papers were published in 2011. In a multicentre German study, the effectiveness of this system (called BridgePoint at that time) in CTO resistant to previous recanalisation attempts was 67% (28/42), and periprocedural complications were rare, with the rate of major adverse cardiac events (MACE) of 4.2% [12].

In the multicentre Facilitated Steering Technique in Chronic Total Occlusions (FAST-CTOs) study [13], the BridgePoint was used in 147 patients with CTO resistant to previous

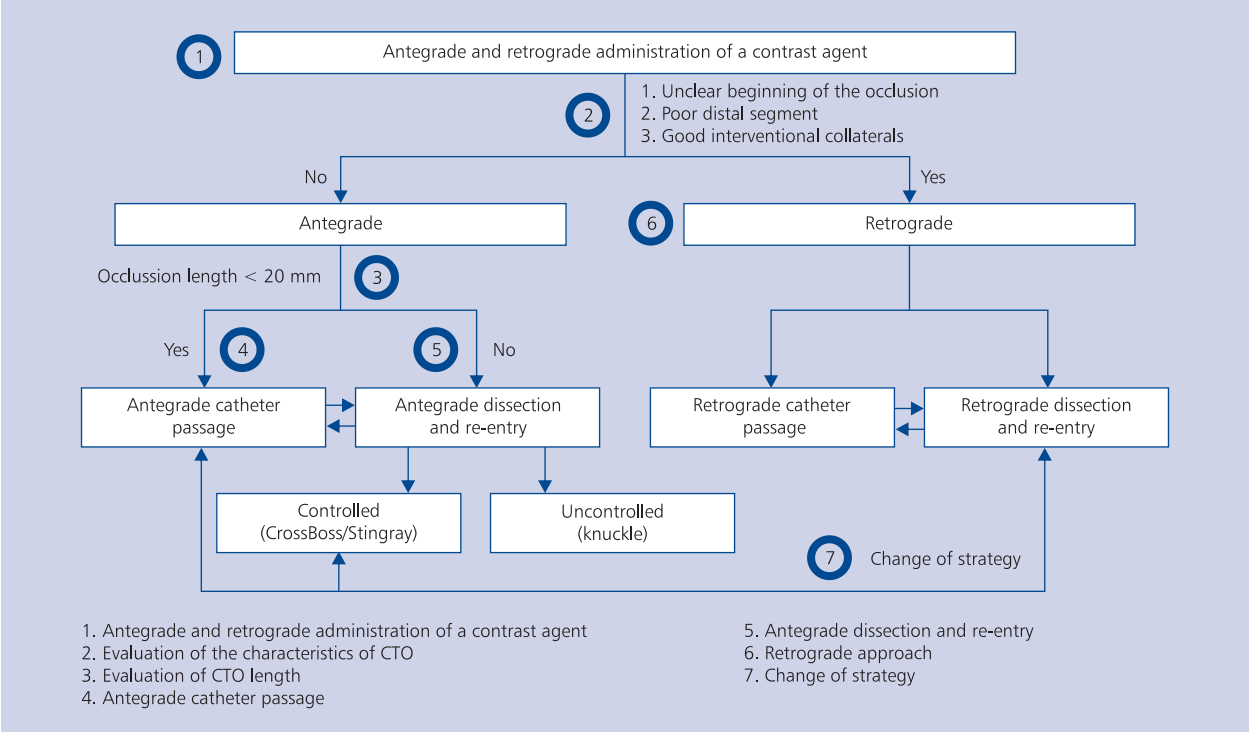

Figure 12. The algorithm for crossing a chronic total coronary artery occlusion (CTO) with an angioplasty guidewire according to Brilakis

recanalisation attempts. The success rate was 77%: in 56 cases, CrossBoss allowed crossing the occluded segment down to the true vessel lumen, and in 59 cases recanalisation was possible with additional use of Stingray balloon and guidewire. Compared to a historical control group, these procedures were more effective (77% vs. 59%, p = 0.001), safer (30-day MACE rate 4.8% vs. 6.9%, p = 0.04), and shorter (procedure duration 105 vs. 146 min, p = 0.0001; fluoroscopy time 44 vs. 52 min, p = 0.0001).

Long-term outcomes of coronary artery stent implantation within the subintimal space were initially a very controversial issue. This was particularly the case with methods associated with extensive and uncontrolled dissection, as in the procedures involving STAR and miniSTAR techniques. Data on long-term effects of the use of the Boston Scientific Coronary CTO Crossing System are scarce. In a retrospective single-centre analysis of 170 CTO recanalisation procedures, 60 patients treated using this system were compared to 110 patients in the control group [14]. Although the first of these patient groups was more challenging in many aspects (more previous unsuccessful recanalisation attempts, higher equipment and contrast agent use, longer duration of the procedures), the rate of repeat target lesion revascularisation during 1.8 years of follow-up (range 1.2–2.4 years) was similar (41% vs. 30%, p = 0.13), as was the rate of MACE (40% vs. 35%, p = 0.42). Angiographic follow-up, however, was performed in only 42.9% of patients.

The Boston Scientific Coronary CTO Crossing System may be successfully used for treating in-stent reocclusion. Among 30 such recanalisation procedures, including 14 performed in vessels after previous unsuccessful recanalisation attempts using conventional techniques, the success rate was 90% (27/30), and in 81% of cases (25/30) the CrossBoss catheter penetrated directly to the true vessel lumen. These procedures were relatively short (113 min), dose area product was 9.1 cGy × cm^2, and no significant complications were noted [15].

This system was also reported to be successfully used in the lower limb arteries [16].

A multicentre European CrossBoss and Hybrid Registry on Coronary Chronic Total Occlusions (RECHARGE) study is currently ongoing [17]. This a registry that started recruiting patients at the beginning of 2014 and intends to collect data on 1000 CTO recanalisation procedures using the CrossBoss catheter and Stingray balloon catheter by early 2016. The aim of this study is to evaluate the effectiveness and safety of CTO recanalisation using an algorithm involving use of the two major components of the Boston Scientific Coronary CTO Crossing System. This will be the largest prospective registry on this issue.

CONCLUSIONS

The Boston Scientific Coronary CTO Crossing System is a useful device for percutaneous recanalisation of chronically occluded coronary arteries. When using it, several points should

be borne in mind: 1) experience with this system should be accrued under guidance of an experienced operator (proctor); 2) it should be treated neither as a panaceum for all CTOs nor the last resort; and 3) its role in the recanalisation algorithm should be well understood, with awareness of both indications and limitations. In experienced hands, use of CrossBoss/Stingray allows safe success within relatively short crossing times and with a limited amount of the contrast agent and X-ray dose.

Conflict of interests: *Julian Strange is a Boston Scientific proctor.*

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Rekanalizacja przewlekle zamkniętych tętnic wieńcowych z wykorzystaniem systemu CrossBoss/Stingray: pierwsze doświadczenia (opis trzech przypadków)

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Streszczenie

Wstęp i cel: Przezskórna rekanalizacja przewlekle zamkniętej tętnicy wieńcowej (CTO) nadal pozostaje zabiegiem trudnym i związanym z mniejszym odsetkiem powodzenia niż klasyczny zabieg przezskórnej interwencji wieńcowej (PCI). Postęp, jakiego jesteśmy świadkami w ostatnich kilkunastu latach, obejmujący nowe prowadniki angioplastyczne, technikę rekanalizacji drogą wsteczną (*retrograde*) oraz technikę dyssekcji podśródbłonkowej i re-entry, pozwala w doświadczonych ośrodkach osiągnąć sukces w 95% przypadków. Podśródbłonowa penetracja prowadnika angioplastycznego przestała być problemem, często kończącym zabieg rekanalizacji. Stała się elementem hybrydowego podejścia do CTO wykorzystywanym zarówno w zabiegach typu *antegrade*, jak i *retrograde*. Nowym narzędziem, kreującym dyssekcję w sposób przewidywalny i kontrolowany, oraz pozwalającym na skuteczny powrót prowadnika angioplastycznego do prawdziwego światła naczynia jest Boston Scientific Coronary CTO Crossing System składający się z mikrocewnika CrossBoss i cewnika balonowego z prowadnikiem Stingray.

Metody: W dniach 29–30 października 2014 r. przeprowadzono rekanalizacje CTO z wykorzystaniem systemu CrossBoss/ /Stingray u 3 mężczyzn w wieku 63–75 lat, z objawami stabilnej dławicy piersiowej (CCS II–III), bez przebytych zawałów serca w obszarach zaopatrywanych przez tętnice z CTO i zachowaną kurczliwością mięśnia sercowego. Wszyscy trzej pacjenci wcześniej zostali poddani co najmniej jednej próbie rekanalizacji *antegrade* lub *retrograde* zmian, których J-CTO score wynosił 3–4.

Wyniki: Zabiegi były skuteczne u wszystkich chorych: u 2 osób zrekanalizowano prawą tętnicę wieńcową, u 1 pacjenta — gałąź międzykomorową przednią lewej tętnicy wieńcowej. U wszystkich chorych wykorzystano zarówno cewnik CrossBoss, jak i system Stingray w celu powrotu do prawdziwego światła naczynia. Implantowano po 2–3 stenty typu DES o łącznej długości 62–106 mm, uzyskując przepływ TIMI 3. Średni czas zabiegów wynosił 141 min (130–150 min), czas skopii rentgenowskiej — 53 min (48–56 min), dawka pochłonięta — 4772 mGy (4098–5633 mGy), dawka powierzchniowa — 565 208 cGy × cm^2 (535 109–590 266 cGy × cm^2), a ilość środka kontrastowego — 343 ml (320–350 ml). Zabiegi przebiegły bez powikłań, poza bezobjawowym wzrostem hsTnT do maksymalnie 157 ng/ml (norma: 0–14 ng/ml) u 1 chorego.

Wnioski: Boston Scientific Coronary CTO Crossing System jest użytecznym narzędziem w zabiegach rekanalizacji przewlekle zamkniętych tętnic wieńcowych. Pomaga w bezpieczny sposób osiągnąć sukces w trudnych przypadkach, zachowując umiarkowany czas zabiegu, dawkę promieni rentgenowskich i ilość środka kontrastowego.

Słowa kluczowe: przezskórna rekanalizacja, przewlekłe zamknięcie tętnicy wieńcowej, CrossBoss, Stingray

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