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Coronary angioplasty guidewires: differential characteristics and technology

Abstract

Coronary angioplasty guidewires (CAG) are one of the elements considered essential for percutaneous coronary intervention (PCI). However, in scientific literature there are not as many publications about them as exist for other devices. In this review, we will analyse the technology, characteristics and classification of the CAGs, paying special attention to their structure and *tip load*.

Keywords: coronary angioplasty, coronary guidewires, percutaneous coronary intervention

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Abbreviations: CAG, coronary angioplasty guidewires; CTO, chronic total occlusion; PCI, percutaneous coronary intervention; FFR, fractional flow reserve

Introduction

The choice of a CAG must be carried out according to the anatomy of the vessel, type of lesion and technique that will be used for its treatment. CAGs usually have a diameter of 0.014inches, although there are those with a smaller diameter such as that which supports rotational atherectomy, which is 0.009inches, and of variable length, which is usually from 175 to 190cm, but which can be up to 330cm. Its distal tip, straight or J-shaped, is usually radio-opaque which aids its visibility while it is being handled, in addition to its use for estimating the length of the lesion. The basic composition of guidewires is well established: central core, distal tip, covering and coating. One of the fundamental characteristics of the tip is its weight or load, *tip load*, as we will discuss shortly, which is very important for the intended design and use of the CAG. For the study of the differential characteristics of the CAGs we will classify them into four groups: for standard use, flexible, high support and for chronic occlusions, which have a high *tip load*, as we will see.

Discussion

Structure of coronary guidewires

The technology involved in engineering guidewires includes three areas: selection of materials, design of the configuration, and development of the construction process to fabricate the CAG.[2] The internal part of the CAG is known as the core, which is extended through the length of the shaft from the proximal to distal tip, where it begins to narrow. It is the most rigid part of the CAG, giving it stability and manoeuvrability and affecting its flexibility, control and support. The distal tip is essential to cross the lesion and a precise direction, it has a specific surface design for the purpose of the use for which it is designed; there are also those such as spring coils of stainless steel, as well as polymeric or plastic coverings and hydrophilic or hydrophobic coverings. Hydrophobic (silicone/Teflon) outer coating aids easy advancement. Hydrophilic outer coating becomes a gel when wet to reduce surface friction and increase wire "slipperiness". Hydrophilic CAGs often help during the procedure, but they are also independently linked to the possibility of coronary perforation during the PCI, although it is a rare complication (0.2-3% according to the data), it can have a bad prognosis due to the risk of cardiac tamponade, necessity of surgery, formation of pseudoaneurysms, arrhythmias or death.[3] Fasseas P et al.,[4] found 95 coronary perforations in a review of 16,298 PCI procedures; of the 95 patients with coronary perforation, 12 patients (12.6%) sustained an acute myocardial infarction and 11 patients (11.6%) developed a cardiac tamponade.[4]

Ellis et al.,[5] classified CAG perforations in the following types. Class I, fuly contained, may be very dificult or impossible to distinguish angiographically from localized dissections. Class II, result in a limited extravasation. In both class I and II perforations there could be a low (<5% to 10%) incidence of delayed tamponade. Class III, brisk extravasation, were associated with a high incidence of complications. And finally, perforation in to an anatomic cavity.[5]

The manipulation of the tip of the CAG allows it to be adapted to coronary and lesion morphology. The most common way of shaping the CAG is over the thumb and index finger, using a guidewire introducer or a needle.[6] The main performance characteristics of the CAG are pushability, flexibility, trackability, crossing, steerability, torque control, feel or tactile feedback, time through anatomy, support, radiopacity, lubricity, lubricity retention, tip shape retention and prolapse tendency.[7]

Differential characteristics of coronary guidewires

Standard CAGs, for common usage, are usually of moderate support and must offer security, 1:1 torque and good memory and durability of the tip, without breaks, and with a low to medium *tip load*. Flexible CAGs are designed for use in very angled vessels, they are usually polymeric, with a medium *tip load* and also of moderate support, with a simple nucleus and 1:1 torque and they must have as a basic feature an excellent capacity for direction through any tortuosity, avoiding perforation and subintimal dissection. High support CAGs are designed to provide more support in cases of tortuous anatomy and distal lesions. Among their features is a soft tip, otherwise there would be a risk of complications given the high support, and the absence of elastic recoil. CAGs for chronic total occlusion (CTO) have a distinct rigidity in the tip, with a medium to high weight, with retention of the shame of the tip and moderate support, a design that aims to avoid the possibility of perforation.

Characteristics and sorting of coronary guidewires according to their *tip load*

The weight or load of the tip, *tip load*, of the CAGs is different in terms of the use for which it is designed, giving them different penetration and navigability capacities. Thus, we find that among the CAGs most commonly used and easy to slide out that the *tip load* varies between 0.5 and 0.9g, as is the case of: the Sion (Asahi) family, with a composite nucleus, they offer excellent torque and hydrophilic covering; Frontline Soft® (Asahi), non-hydrophilic CAG with a silicon covering on the coil and which has excellent touch feedback; Frontline Light® (Asahi), which has a flexible nucleus to facilitate access to distal branches; the CAG Rider® (Balton), with hydrophilic coating for optimal crossing of tortuous and narrow vessels and a great steerability and precise manipulation; Champion® (SP Medical) with PTFE coating and platinum tip hydrophilic coated, silicone coated or uncoated; BMW® (Abbott Vascular) which offers moderate support and durability of the tip; Cruiser® (Biotronik), with Hydrophobic coating, offers optimized pushability and 3 tip flexibilities; Galeo Pro® (Biotronik), with Hydrophilic coating, features improved durability and better control; and, Rinato/Prowater® and Route/Prowaterflex® (Asahi), floppys and with moderate support, they also have a silicon covering on the coil that makes the procedure safer.

With a low *tip load* we also find the high support CAGs , which have a rigid shaft, as is the case of the Grand Slam® (Asahi) with a tip load of 0.7g; the Hi-Torque Extra S´Port® (Abbott Vascular), that has a hydrophobic covering, with a *tip load* of 0.9g; the Hi-Torque Iron Man® from (Abbott Vascular), with a nucleus of stainless steel up to the tip and hydrophobic covering, and a tip load *de* 1 g. Among polymeric CAGs *tip load* varies between 0.8 to 1.5g and 2 to 4g. The coating of these CAG gives them great traceability and sliding capacity, with a fine control over the CAG, as well as greater torque and support; they are developed for complex and diffuse lesions. Within the first polymeric CAGs we find Fielder® (Asahi) and Whisper® and Hi-Torque Pilot 50® (Abbott Vascular); while among those with the highest *tip load* we find the PT® (Boston Scientific) family: PT Graphix®, PT Choice® and PT 2®. As Meier B explains, a diligent control of the distal tip of hydrophilic wires at all times and in all positions is thus warranted but easily neglected once the occlusion is passed and the job considered done.[8]

Sometimes the use of the jailed CAG technique is necessary when treating bifurcation lesions; however, the CAG can suffer damage in both polymer coated and nonpolymer-coated, according Villanueva E et al.,[9] damage was more common in nonpolymer-coated CAG ($P < .001$).[9] CAGs designed for treating CTO have a much greater *tip load* that is usually between 3 and 20g, sometimes more, but there are also those with smaller tip weights as is the case of the Cross-it 100® (Abbott Vascular) with 1.7g. Among the CAGs for CTO the following guidewires stand out from Asahi: Intermediate®, which would be one of the first choices for CTO, has a silicon covering on the coil and a *tip load* of 3g; Ultimatebros 3®, which is differentiated by its long hydrophilic covering; Miracle® y Miraclebros®, with a *tip load* between 3 and 12g, for progressive complexity of CTO, with a greater component of fibrous or calcified plaque; and the Conquest® and Confianza® with t*ip loads* between 9 and 20g, designed to penetrate lesions from those that are highly stenotic to those that are calcified and fibrous and, ultimately, complex and very calcified occlusions. The Crosswire® (Terumo) family represents a PCI guidewire family designed for complex and CTO lesions featuring moderate support, they have a tip load between 5.5 and 66.2g, its polyurethane distal section is made with hydrophilic coating and a nickel-titanium alloy (Nitinol) single core. The CAG HT Pilot® 150 and 200 (Abbott Vascular), with *tip load* of 2.7 and 4.1g respectively, are also used in CTO.

Intracoronary guide for the calculation of coronary reserve

This is a CAG 0,014 which allows us to find out the coronary distal pressure of a lesion, usually of doubtful severity. It is a tool that is integral to normal practice in the Hemodynamic laboratorios since the end of the nineties, as one of the intracoronary diagnostic techniques.[10] Using this information the fractional flow reserve (FFR) can be calculated, which is defined as the ratio between the distal pressure of the lesion (recorded by the pressure sensor in the CAG) and the proximal pressure of the lesion (which is obtained by the pressure line connected to the catheter). The CAG for calculating the FFR requires an independent review, due as much to its different characteristics as its purpose (Table 1 & 2).

Table 1 Examples of different coronary angioplasty guidewires according to their differential characteristics

Standard	High Support	Flexible	Chronic Total Occlusion
Sion	Grand Slam	PT Graphix	Intermediate
Rider	Hi-torque Extra sport	PT 2	Cross-it
Champion	Hi-torque Iron Man	Whisper	MiracleBros
Cruiser	Rider stiff	Pilot 50	Confianza, Conquest
Galeo Pro	Cruiser ES	PT Choice	Pilot 150 y 200
BMW		Asahi Fielder	Champion CTO

Table 2 Classification of guides according to their tip load

Standard	High Support	Flexible	Chronic Total Occlusion
0,5 – 0,9 g	0,7 – 1 g	0,8 – 4 g	1,7 – > 20 g
Sion	Grand Slam	Fielder	Intermediate
Rider	Hi-Torque ES´Port	Whisper	Ultimatebros
Champion	Hi-Torque Iron Man	Hi-Torque Pilot 50	Miracle
Galeo Pro	Rider stiff	PT Graphix	Conquest, Confianza
Frontline Soft	Cruiser ES	PT Choice	Crosswire
BMW		PT 2	Champion CTO
Rinato/Prowater			Pilot 150 y 200

Conclusion

CAGs are an essential element of coronary interventionism. The guidewire selection is an important component of a PCI, as they have great implications in successfully crossing the lesion and in the support of the devices that will be used. The choice depends largely on the experience of the operator, who should equally consider other factors such as the characteristics of the lesion, its severity and the anatomy of the vessel.

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Conflicts of interest

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