Case Report

Perigraft Leak of an Aortic Stent Graft Due to Material Fatigue

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In elective surgical treatment of abdominal aortic aneurysms, graft failure rates for 1974–1979 were 2% on average, and operative mortality rates were between 2% and 4% [1]. Because of this relatively high mortality rate and frequent complications during and after surgical treatment of aortic aneurysms in high-risk patients, a general trend toward minimally invasive techniques emerged, leading to the development of transfemoral implantable stents. During feasibility studies with sheep, small pigs, and dogs [2], stent design and implantation techniques improved rapidly. The first transfemoral implantations in humans were reported by Parodi et al. [3] and Volodos et al. [4] in 1991. Since then, the first short-term follow-up studies have shown that transfemoral implantable stents can be a valuable alternative to surgery [5, 6]. Long-term results are not yet available, but controlled clinical multicentric studies are already in progress [7].

The first aortic stent commercially available in Europe was the Stentor device (Minimally Invasive Technologies, Freeport, Bahama Islands), a larger version of the Cragg EndoPro System 1 (Minimally Invasive Technologies) [2]. The Stentor device is constructed of shape-memory nitinol monofilaments fastened together by a 7-0 polypropylene ligature into a tubular zigzag configuration. The resulting metallic framework is covered by thin woven polyester fabric [6]. In our report, the covering of the stent had a longitudinal suture. In later versions of the stent, the suture was replaced by seamless tubular woven material.

Case Report

A 72-year-old man with Parkinson's disease, vitamin B_{12}–deficiency anemia, arterial hypertension, and cardiac arrhythmia underwent transluminal implantation of an endoluminal stent (length, 100 mm; diameter, 24 mm) for treatment of an infrarenal aortic aneurysm (maximum diameter, 4 cm). Preoperative digital subtraction angiography showed severe elongation of the infrarenal aorta. After stent implantation, digital subtraction angiography showed the stent closely following the elongation of the infrarenal aorta (Fig. 1A).

Routine follow-up included helical CT angiography at 3, 6, and 12 months (Somatom 4 Plus; Siemens, Erlangen, Germany). The following parameters were used for CT angiography: slice thickness, 5 mm; table feed, 10 mm; increment, 5 mm; nonionic contrast material, 120 ml; infusion rate, 4 ml/sec; and scan delay, 25 sec. A helical CT angiogram obtained 18 months after implantation showed a major perigraft leak in the proximal region of the stent, 3 cm distal to the aneurysmal neck (Fig. 1B). No proximal perigraft leak was seen. A second helical CT angiogram obtained 4 weeks later showed the same major perigraft leak. Under fluoroscopic guidance, a nearly circumferential dehiscence of the nitinol filaments in the region of left convex elongation was evident (Fig. 1C).

Because the opposing monofilaments were intact, we suspect that the dehiscence resulted from the breakdown of the polypropylene ligature, which was probably caused by increased stress in the region of the steeper curvature. How the polyester covering was damaged, leading to the perigraft leak, remains unclear: Either the suture opened or the nitinol filaments poked a hole in the fabric. A possible mechanism of stent disintegration included buffering of the blood pressure waves by the kink in the stent in the early stage, leading to disintegration of the polypropylene material fastening the nitinol filaments; then the loose filaments damaged the polyester fabric covering the metal framework and caused the perigraft leak (Fig. 2).

Because of the major destruction of the mesh and the covering of the stent and the danger of further dehiscence caused by interventional measures, endoluminal repair by embolization was not possible. Therefore, 20 months after initial stent implantation, a second stent of the same size was transfemorally implanted in the same location. A digital subtraction angiogram obtained before stent implantation showed the broken stent (Fig. 1D). The second stent implantation was performed without complications (Fig. 1E). The patient showed early signs of postoperative sinus

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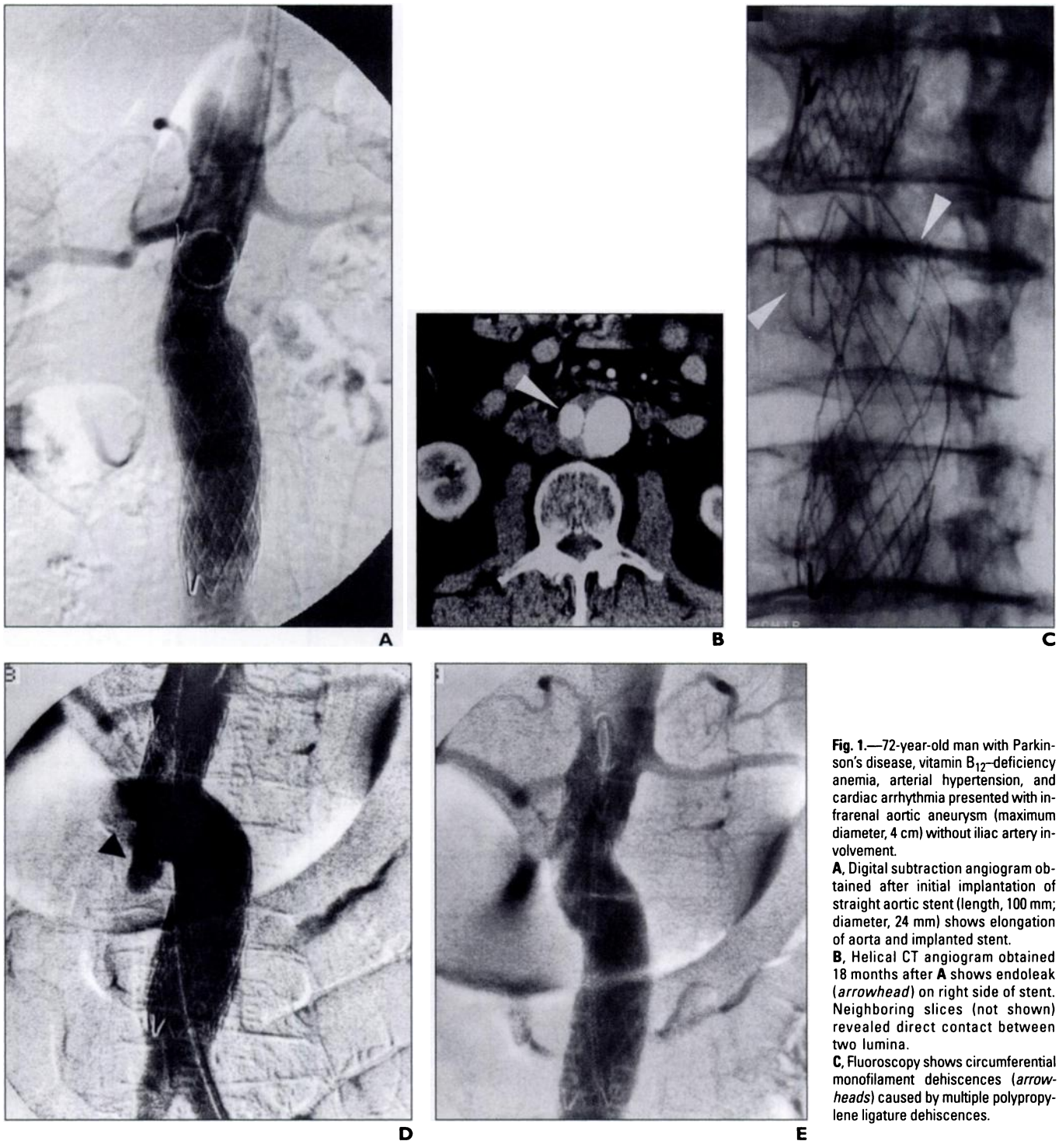

Fig. 1.—72-year-old man with Parkinson's disease, vitamin B_{12}–deficiency anemia, arterial hypertension, and cardiac arrhythmia presented with infrarenal aortic aneurysm (maximum diameter, 4 cm) without iliac artery involvement.

A, Digital subtraction angiogram obtained after initial implantation of straight aortic stent (length, 100 mm; diameter, 24 mm) shows elongation of aorta and implanted stent.

B, Helical CT angiogram obtained 18 months after **A** shows endoleak (*arrowhead*) on right side of stent. Neighboring slices (not shown) revealed direct contact between two lumina.

C, Fluoroscopy shows circumferential monofilament dehiscences (*arrowheads*) caused by multiple polypropylene ligature dehiscences.

D, Digital subtraction angiogram obtained before second stent implantation shows broken stent (*arrowhead*) and extravasation of contrast medium.

E, Digital subtraction angiogram obtained after implantation of second stent to repair leak shows successfully placed stent of same type in same location.

bradycardia and was transferred to the emergency department for observation. Further complications did not occur. Follow-up helical CT performed 3 and 6 months after the second implantation showed no evidence of a persistent perigraft leak.

Discussion

The feasibility and efficiency of transluminal placement of aortic stents have been

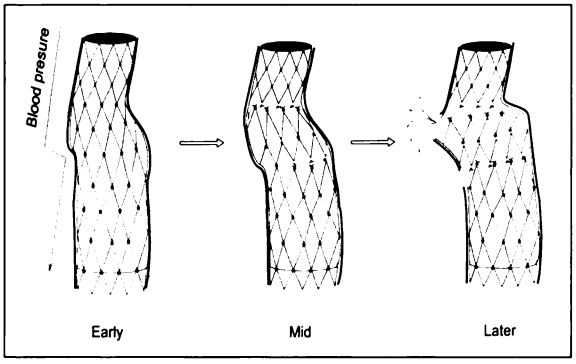

Fig. 2.—Drawing shows suspected mechanism of stent disintegration. Blood pressure waves are buffered by kink in stent (early) leading to disintegration of polypropylene material that fastened nitinol filaments (mid). Then loose filaments damage polyester fabric covering metal framework, causing perigraft leak (later).

shown in a wide range of laboratory [2] and clinical [3] studies. The advantages of minor invasiveness, a shorter hospitalization, and reduced cost are evident. However, long-term results are not available, and the first multicenter studies are not yet finished [7].

The present clinical case shows that the first generation of an aortic stent can, under certain circumstances, develop a perigraft leak due to ligature dehiscence. This kind of leak, which is associated with damage of the polyester fabric covering, could not be treated by transcatheter embolization and instead required stent reimplantation.

The risks of untreated leaks are great. Untreated endoleaks and collateral perfusion of the aneurysmal sac have a 12 times higher risk of further aneurysmal dilatation [8]. However, until more data on untreated endoleaks are available, the differences between the risk of further aneurysmal dilatation for different groups of endoleaks remain unclear.

In the present case, suspected risk factors leading to stent disintegration were severe aortic elongation and a rapid change in vessel diameter, calcifications of the curvature, and the inferior quality of the material used for the Stentor device. The succession of steps during stent disintegration remains unclear: Either dehiscence of the filaments caused breakdown of the covering fabric or breakdown of the fabric caused dehiscence of the filaments.

Two mechanisms by which the polyester stent covering developed leaks are possible: Either parts of the suture came undone (inferior material quality under stress of sheer force) or loose nitinol filaments damaged the fabric wall. The fact that both filament dehiscence and leakage of cover material occurred on the patient's right side makes the latter mechanism more probable. Clearly, the polypropylene material that fastened the nitinol filaments together disintegrated. Connecting material such as polypropylene must be able to tolerate full aortic blood pressure at a frequency of 80 pulses per minute on average. In the present case, the curvature of the aorta caused a kink in the stent that then was unable to withstand the blood pressure waves. This failure may indicate the need for a connective material with greater elasticity between the nitinol filaments. Whether the changes in the fabrication of a new generation of Stentor devices (seamless tubular woven polypropylene covering) have already diminished the probability of such material fatigue remains unclear. If the leading cause of breakdown was mechanical damage of the cover by nitinol filaments and not disintegration of the suture, then the danger of material fatigue remains unresolved and further changes in stent design are necessary.

By the publication of this case report, we hope that the necessity of regular follow-up—especially for patients who received first-generation Stentor devices with a nontubular covering—has become clear. Until recommendations from long-term follow-up studies are obtained, follow-up intervals of no more than 1 year for at least 5 years after stent implantation are advised. The present case shows that regular fluoroscopy is useful in assessing filament integrity, because filament dehiscences cannot be seen using CT angiography. For this reason, fluoroscopy should be used as a screening method for filament dehiscences in the meantime between CT angiography examinations and in intervals of no more than 6 months.

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