Cardiovasc Intervent Radiol (2007) 30:814–819
DOI 10.1007/s00270-007-9123-5

REVIEW/STATE OF THE ART

Standards for the Endovascular Management of Aortic Occlusive Disease

Raman Uberoi · Dimitrios Tsetis

Received: 23 April 2007 / Accepted: 19 May 2007 / Published online: 21 July 2007

Abstract Occlusive disease of the infrarenal aorta and aorto-iliac arteries can be safely treated by minimally invasive therapy and is now widely available. The aim of this article is to produce standards for the management of these patients using current endovascular techniques.

Keywords Interventional radiology · Atherosclerosis · Aortic · Iliac · Stenting · Angioplasty

In patients with ischemic peripheral atherosclerotic disease, the infrarenal abdominal aorta and the iliac arteries are the most commonly involved sites affected by the atherosclerosis [1]. Lesions are generally diffuse and involve the aorta and iliac segments [1]. Localized stenosis or occlusion of the infrarenal aorta above the aortic bifurcation, however, occurs relatively infrequently. In contrast to the male predominance in chronic multilevel atherosclerotic disease (male-female ratio, ~6:1), most patients with localized aortic lesions are women aged 30 to 50 years [2]. The most important risk factors are heavy smoking, abnormal blood lipid concentrations[3, 4], and so-called hypoplastic aorta syndrome [5], Size criteria for aortic hypoplasia include infrarenal aortic diameter <13.2 mm, or < 10.3 mm just above the aortic bifurcation [4]. Patients with more diffuse or multilevel stenotic lesions are much more likely to have other risk factors, such as hypertension, diabetes, or associated atherosclerotic disease of the coronary or cerebral arteries.

Traditionally, endarterectomy was the treatment of choice for localized aortic stenosis and aortobifemoral or extra-anatomic bypass for more extensive disease. However although surgery delivers durable results, it is associated with significant peri-operative mortality and morbidity [6, 7]. The potential for graft infection is a particular drawback of extra-anatomic bypass. Endovascular treatment delivers hemodynamically acceptable results that are likely to be better than those of extra-anatomic bypass. It is likely that recovery and mobilization can occur much sooner after endovascular procedures, with a potential for lower morbidity, mortality, and costs.

After Dotter and Judkins [8] introduced percutaneous transluminal angioplasty (PTA) in 1964, balloon angioplasty became a feasible alternative treatment for small and medium occluded or stenotic arteries. With the introduction of larger balloons it was possible to treat stenosis in major vessels such as the aorta, with the first reported cases in 1980 [9, 10]. Initially, however, this still required the use of a “kissing balloon” technique, with simultaneous inflation of two or more balloons in the aorta to give an adequate diameter, and this technique is also advocated for treating lesions involving the distal aorta and common iliac arteries [11–14].

With the development of larger stent technology, selective [15–17] and, more recently, primary stenting of the aorto-iliac segments has been advocated with bare stents [18–22] and covered stent-grafts [23, 24]. Many subsequent studies have demonstrated the initial advantages of PTA over surgery, including shorter hospital stay, lower complication rate, and less invasive technique [25–28].

Indications include pelvic and lower limb ischemia (short-distance claudication, critical ischemia, blue toe

R. Uberoi (✉)
Department of Radiology, The John Radcliffe Hospital, Headley Way, Headington, Oxford OX3 9DU, UK
e-mail: raman.uberoi@orh.nhs.uk

D. Tsetis
Department of Radiology, University Hospital of Heraklion, Heraklion, Crete, Greece

syndrome) due to atherosclerosis or Takayasu's disease (TASC A and B).

Contra-indictions are related to any percutaneous intervention (groin sepsis, bleeding diathesis, or severe coagulopathy) or TASC D-type lesion. Relative contra-indications include anticoagulation, contrast allergy (CO_2 or gadolinium can be used as alternative contrast), heavy concentric calcification of the aorta, active arteritis, and TASC C-type lesion.

Technique of Intervention

Imaging

Patient selection has evolved from using a combination of clinical assessment, including ABPI followed by angiography, to include duplex assessment [20, 29] and/or computed tomography (CT) [15, 17, 21] prior to invasive angiography to allow accurate assessment and sizing of lesions. Noninvasive imaging, wherever possible, is now widely used to select patients for endovascular management. At our institution we use duplex ultrasound as the first line to assess the peripheral circulation including the aorto-iliac segments for occlusive atherosclerotic disease. If this is inconclusive, we use either CT angiography (CTA) or magnetic resonance angiography (MRA) to plan management prior to invasive angiography and intervention. MRA is particularly useful in patients with heavily calcified vessels, which results in shadowing on ultrasound and artifact on CT, and in obese patients with impaired renal function or iodinated contrast medium allergy.

Angioplasty

The procedures are normally performed under local anesthetic with full cardiorespiratory monitoring. For difficult and prolonged procedures, facilities for sedation and analgesia should be available. Ideally patients should be commenced on low-dose asprin (150 mg/day) at least 24 h prior to the procedure. Access is usually obtained percutaneously using a single femoral arterial approach for single-balloon angioplasty or aortic stenting, or bilateral common femoral access is established when carrying out kissing balloon angioplasty and/or stenting. Although some authors have also used formal surgical cutdown [19], in which case procedures were performed under general anesthesia. This is followed by the administration of 5000 U of heparin. Duplex ultrasound can be very useful to guide percutaneous arterial puncture in patients with poorly palpable arterial pulses, particularly in obese patients. The lesion/lesions are then often crossed using hydrophilic guide wires and selective catheters, e.g., C 2 Cobra, which are then exchanged for stiffer wires. Sometimes a brachial approach may also be required to help cross difficult lesions [30] and is useful for reference imaging. Thrombolysis can be used safely to help open up even chronically occluded aorta's [31, 32], however, this does prolong the procedure. Before a sheath is positioned across the lesion or a balloon dilatation is performed, luminal position of the wire beyond the occlusion should be confirmed. Appropriately sized sheaths are then advanced proximal to or across the lesion over a stiff guide wire such as the Amplatz superstiff.

Initially balloon sizes were limited and a kissing technique was employed, with two or even three balloons, in order to give the required diameters. However, now a wide variety of balloons is available for use in the aorta, including cutting balloons [33]. For stenosis just proximal to the aortic bifurcation or involving the common iliac artery origins, the "kissing balloon" technique is employed [11–14]; otherwise a single balloon is used for aortic dilatation. Balloon size is determined by preprocedural imaging but should be less than the maximum of the measured aorta diameter and, for kissing balloons, the ipsilateral common iliac arteries and the distal aorta [34, 35]. However, care should be taken during inflation if patients experience severe pain (not possible to assess in patients under general anesthesia). Using a smaller balloon initially may be safer, and if the patient does not experience severe pain, a larger balloon may then be employed.The inflation times, number of inflations, and pressure developed inside balloons vary with operators and equipment and there is no evidence of any difference in outcome with these different practices.

Stenting

Stenting may be performed as a primary or secondary procedure. The majority of stents to date have been placed following angioplasty on the basis of selective criteria, including nearly or totally occlusive aortic lesions, a persistent transstenotic mean pressure gradient >5 mm Hg (or >10 mm Hg higher during pharmacologically induced vasodilatation), ≥30% residual stenosis, and occurrence of dissection.

Predilatation may also be performed to facilitate primary placement of stents [20, 29], however, primary stent placement without predilatation (so-called "direct" stenting) has been advocated by some authors [22] as the treatment of choice, as there is some evidence that this results in less intimal hyperplasia [35]. It is suggested that primary (or direct) stenting may be particularly good for complex stenosis (irregular, eccentric, ulcerated, or calcified lesions) and occlusions. In these cases immediate success may be improved by eliminating luminal irregularities such as protruding plaques and intimal dissections

[36]. A further theoretical rationale for primary stenting is to potentially reduce distal embolization by trapping atheroma and clot between the stent and the arterial wall [36, 37]. However, there is no solid evidence in the literature to recommend primary (or direct) stenting for specific lesion types. A variety of balloon-mounted and self-expanding bare stents is now available on the market. Some self-expanding stents up to 14 mm in diameter can be delivered through sheaths as small as 6 Fr. Although experimentally self-expanding stents appear to cause less neointimal hyperplasia compared to balloon-mounted stents [38], currently there is no clinical evidence of any long-term advantage of one type of stent over the others. However, accurate placement can be difficult with the Wallstent due to stent shortening during delivery, and for larger aortas sometimes a balloon-mounted stent such as the Palmaz is necessary. Balloon-expandable stents should not always be sized to a maximum of the native aorta immediately proximal or distal to the diseased segment, depending on the patient's experience of pain during predilatation PTA. Self-expanding stents should be oversized by 10%.

As described for angioplasty, the lesions are crossed, the sheaths are placed (ideally for balloon-mounted stents across the lesion), the stent or stents are then positioned, and the stents are deployed (the sheaths first having been withdrawn for balloon-mounted stents). Postdeployment PTA is often necessary to fully and uniformly dilate self-expanding stents, particularly if there is a significant resting transstenotic gradient of >10 mm Hg.

Kissing Stents

It is now common practice to use the "kissing stent" technique by deploying the stents simultaneously and re-creating the aortic bifurcation when dealing with the distal aortic segment including the origins of the common iliac arteries [30, 36, 39–44). Kissing stents should ideally extend 5–15 mm into the distal aorta [41, 42]. However, care should be taken to prevent overhanging of one iliac stent over the other in the distal aorta, as this may lead to a significant increase in contralateral stent failure [41, 43, 45]. Another potential disadvantage of this technique is that uncovered metallic struts of the opposing stents protruding into the distal aorta may cause thrombosis and hemolysis. To avoid overdilatation, final balloon diameters should be sized based on the distal iliac reference segment [40].

Aftercare

The vast majority of procedures are carried out percutaneously, and femoral compression has traditionally been used for hemostasis in these patients, with bedrest for 4–6 h. With the development of closure devices, the time to ambulation can be significantly reduced without an increase in complications and with greater comfort for both operator and patient [46, 47]. Using the Prostar suture device (Abbott Laboratory, Redwood City, CA) or Perclose technique, puncture sites as large as 26 Fr can be closed percutaenously [48].

Antiaggregant/Anticoagulation Postprocedure

There is variability in practice, however, all patients should receive anti-aggregant therapy (aspirin, 100 to 325 mg/day) at the time the indication for PTA is made, which should be continued for at least 6 months [39] and, preferably, for life, if there are no contra-indications. Dypridamole may be added (50–325 mg) for 3–6 months or Ticlodipine [43, 49]. Clopidigril may also be substituted. Some authors continue heparin for a period of 24–48 h postprocedure, particularly in difficult cases [22, 29, 39, 44], and a few have placed patients on long-term warfarin anticoagulation [31, 39].

Follow-up

It is incumbent on all interventionists carrying out endovascular procedures to document objective outcomes (e.g., treadmill testing), symptomatic improvement, quality of life, and proof of patency (i.e., duplex ultrasound, CTA, MRA, or angiography).

Immediate technical success has generally been defined as a <30% residual stenosis and or a mean resting transstenotic gradient of <5 mm Hg (or <10 mm Hg peak systolic).

There has been no consistent approach to long-term follow-up. Clinical assessment, including ABPI, is commonly performed [20, 31, 32, 40, 44, 50], with or without femoral Doppler. A persistent increase in ABPI of >0.1 compared to pretreatment is considered significant. Many other authors also carry out duplex ultrasound in addition to this to directly assess patency [21, 30, 39, 40, 51, 52], with selective angiography in a few cases where problems are identified. Only a few have routinely performed follow-up angiography [22, 41].

Outcomes

Over the years several studies have been published on the endovascular management of aorto-iliac occlusive disease. However, the number of patients treated in the majority of these has been small, and there been an inconsistent approach in assessing outcome and follow-up protocols, as well as marked heterogeneity of lesions treated in the abdominal aorta. This makes direct comparison of these studies difficult.

Table 1 Balloon angioplasty [11, 29, 31, 34, 49–51, 53–65]

Patients (6–102)	Technical success	Clinical success	Primary patency: 1 yr/2 yr/4 yr/5 yr	Major complications	Mortality
Range	83%–100%	66%–100%	90%–100%/80%–89%/70%–93%/64%–70%	0%–18.5%	0%–3%
Mean	96%	94%	85% (mean follow-up 4–52 mo)	3.6 %	0.4%

Table 2 Stenting [18–22, 30, 32, 39–45, 52, 66–69]

Patients	Technical success	Clinical success	Primary patency: 1 yr/2 yr/3 yr	Major complications	30-day mortality
Range	93%–100%	83%–100%	100%/91.6%–100/83%–100%	0%–25%	0%–6.0%
Mean	96%	99%	92% (mean follow-up 3–19 mo)	0.4%	0.5%

With the development of stent technology, this was initially performed on a selective basis following failure of angioplasty [16, 46, 61, 64], but more recently it has been advocated as the primary treatment in selective patients [18–20]. Although initial results show some improvement with angioplasty alone, the small number of cases make any firm conclusions impossible. A randomized trial would help to resolve this question.

Although surgery provides an excellent long-term outcome in patients with aortic occlusive disease, it has also been associated with a perioperative mortality rate of up to 1%–7% and a major early complication rate of 9%–27%, including sexual dysfunction, ureteral damage, intestinal ischemia, and spinal cord injury [6, 7, 22].

Endovascular management appears to be a safe and effective alternative to the surgical management of these patients, with low morbidity and high technical and clinical success (Tables 1 and 2). Durability results have also been encouraging. d'Othee et al. (35 patients) reported 85% primary patency at 3 years; de Vries et al. (69 patients) reported primary and secondary patency of 75% and 97%, respectively, at 5 years; and Feugier et al. (86 patients) reported primary patency rates of 89% and 77% at 3 and 5 years, respectively [16, 17, 46].

Complications

Complications following endovascular interventions compare very favorably with those following surgery (Tables 1 and 2). Total mean complications are 10.4% for angioplasty (major complications, 3.6%) and 12.3% for stenting (major complications, 0.4%). The major complications on the whole have been occlusive, i.e., iliac artery occlusion, iliofemoral thrombosis, distal embolization, and aorto-iliac dissection [19], the others being access-site hematoma, pseudo-aneurysm, puncture-site infection, infected stent, and myocardial infarction. Good technique with adequate anti-aggregant therapy and periprocedural heparinization is therefore vital in minimizing complications.

Conclusion

Recognition that occlusive disease of the infrarenal aorta can be safely treated by endovascular therapy is essential for the promotion of this technique. Prospective studies are required to compare endovascular techniques with the conventional surgical alternatives in terms of safety, efficacy, durability, and economy.

References

1. DeBakey ME, Lawrie GM, Glaeser DH (1985) Patterns of atherosclerosis and their surgical significance. Ann Surg 201:115
2. Staple TW (1968) The solitary aortoiliac lesion. Surgery 64:569
3. Brewster DC (1991) Clinical and anatomical considerations for surgery in aortoiliac disease and results of surgical treatment. Circulation 83(Suppl I):142–152
4. Cronenwett JL, Davis JT Jr, Gooch JB, Garrett HE (1980) Aortoiliac occlusive disease in women. Surgery 88:775–784
5. Greenhalgh RM (1979) Small aorta syndrome. In: Bergan JJ, Yao JST (eds) Surgery of the aorta and its body branches. Grune & Stratton, New York, pp 183–190
6. Brewster DC (1995) Direct reconstruction for aortoiliac occlusive disease. In: Rutherford RB (ed) Vascular surgery. W. B. Saunders, Philadelphia, pp 766–794
7. de Vries SO, Hunink MG (1997) Results of aortic bifurcation grafts for aortoiliac occlusive disease: a meta-analysis. J Vasc Surg 26:558–569
8. Dotter CT, Judkins MP (1964) Transluminal treatment of arteriosclerotic obstruction: description of a new technique and a preliminary report of its application. Circulation 30:654–670
9. Grollmann JR Jr, Del Vicario M, Mittal AK (1980) Percutaneous transluminal abdominal aortic angioplasty. AJR 134:1053–1054
10. Tegtmeyer C, Wellons HA, Thompson RN (1980) Balloon dilatation of the abdominal aorta. JAMA 244:2626–2637
11. Belli AM, Hemingway AP, Cumberland DC, Welsh CL (1989) Percutaenous transluminal angioplasty fo the distal abdominal aorta. Eur J Vasc Surg 3:449–453
12. Ravimandalam K, Rao VRK, Kumar S, Gupta AK, Santosh J (1991) Obstruction of the intfra-renal portion of the abdominal aorta results of treatement with balloon angioplasty. AJR 156:1257–1260
13. Palmer FJ, Warren BA (1988) Multiple cholesterol emboli syndrome complicating angiographic techniques. Clin Rad 39:519–522

14. Dragan S, Sreten G, Miodrag P, Zoran P, Bozina R, Miovan B (1995) “Kissing balloon” technique for abdominal aorta angioplasty Initial results and long term outcome. Int Angiol 14:364–367
15. Derom A, Vermassen F, Ongena K (2001) PTA and stenting after previous aorto-iliac endarterectomy. Eur J Vasc Surg 22:130–133
16. D’ Othee BJ, Haulon S, Mounier-Vehier C, Beregi JP, Jabourek O, Willoteaux S (2002) Percutaneous endovascular treatement for stenoses and occlusions of infra-renal aorta and aortoiliac bifurcation midterm results. Eur J Vasc Endovasc Surg 24:516–523
17. Feugiere P, Toursarkissian B, Chevalier JM, Favre JP (2003) Endovascular treatment of atherosclerotic stensosis of the infrarenal abdominal aorta. Long term outcome. Ann Vasc Surg 17:375–385
18. Sheeran SR, Hallisey MJ, Ferguson D (1997) Percutaneous transluminal stent placement in the abdominal aorta. J Vasc Interv Radiol 8:55–60
19. Nyman U, Uher P, Lindh M, et al. (2000) Primary stenting in infrarenal aortic occlusive disease. CardioVasc Interv Radiol 23:97–108
20. McPherson SJ, Laing AD, Thomson KR, et al. (1999) Treatment of infrarenal aortic stenosis by stent placement: a 6 year experience. Australas Radiol 43:185–191
21. Yilmaz S, Sindel T, Yegin A, et al. (2004) Primary stenting of focal atherosclerotic infrarenal aortic stenosis: long term results in 13 patients and a literature review. CardioVasc Interv Radiol 27:121–128
22. Poncyljucz W, Falkowski A, Garncarek J, Karasek M, England S, Zaierucha D (2006) Primary stenting in the treatment of focal atherosclerotic abdominal aortic stenoses. Clin Rad 61:691–695
23. Ali AT, Modrall JG, Lopez J, et al. (2003) Emerging role of endovascular grafts in complex aortoiliac occlusive disease. J Vasc Surg 38:486–491
24. Maynar M, Zander T, Qian Z, et al. (2005) Bifurcated endoprosthesis for treatment of aortoiliac occlusive lesions. J Endovasc Ther 12:22–27
25. Martinez R, Rodriguez-Lopez J, Diethrich EB (1997) Stenting for abdominal aortic occlusive disease: long term results. Tex Heart Inst J 24:15–22
26. Houlon S, Mounier-Vehier C, Gaxotte V, et al. (2002) Percutaneous reconstruction of the aortoiliac bifurcation with the “kissing stents” technique. J Endovasc Ther 9:363–368
27. Jeans WD, Danton RM, Baird RN, Horrocks M (1986) A comparison of the costs of vascular surgery and balloon dilatation in lower limb ischemic disease. Br J Radiol 59:453–456
28. Doubilet P, Abrams HL (1984) The cost of underutilisation: percutaneous transluminal angioplasty for peripheral vascular disease. N Engl J Med 310:95–102
29. Tegtmeyer CJ, Kellum CD, Kron IL, Mentzer RM Jr (1985) PTA in the region of the aortic bifurcation: the two balloon technique with results and long term follow up study. Radiology 157:661–665
30. Vallabhaneni SR, Bjorses K, Malina M, Dias NV, Sonesson B, Ivancev K (2005) Endovascular management of isolated aortic occlusive disease is safe and effective in selected patients Eur J Vasc Endovasc Surg 30:307–310
31. Pilger E, Decrinis M, Stark G, et al. (1994): Thrombolytic treatment and balloon angioplasty in chronic occlusion of the aortic bifurcation 1. Ann Intern Med 120:40–44
32. Diethrich EB, Santiago O, Gustafson G, et al. (1993) Preliminary observations on the use of the Palmaz stent in the distal portion of the abdominal aorta. Am Heart J 125:490–501
33. Joseph G, Pati PK, Mathews P (2003) Multivessel cutting balloon angioplasty in a patient with type III nonspecific aortoarteritis. Indian Heart J 55:175–177
34. Audet P, Therasse E, Oliva VL, et al. (1998) Infrarenal aortic stenosis: long term clinical and hemodynamic results of percutaneous transluminal angioplasty. Radiology 209:357–363
35. Harnek J, Zouca E, Stenram, Cwikiel W (2002) Insertion of self-expandable Nitinol stents without previous balloon angioplasty reduces restonsis compared with PTA prior to stenting. CardioVasc Interv Radiol 25:430–436
36. Onal B, Ilgit ET, Yucel C, Ozbek E, Vural M, Akpek S (1998) Primary stenting for complex atherosclerotic plaques in aortic and iliac stenoses. CardioVasc Interv Radiol 2:386–392
37. Karkos CD, D’Souza SO, Hughes R (2000) Primary stenting for chronic total occlusion of the infrarenal aorta. J Endovasc Ther 7:340–344
38. Chuapetcharsopon C, Wright KC, Wallace S, Doobben RL, Gianturco C (1992) Treatment of experimentally induced atherosclerosis in swine iliac ateries: a comparison of self-expanding and balloon-expanded stents. CardioVasc Interv Radiol 15:143–150
39. Nawaz S, Cleveland T, Gaines P, Beard J, Chan P (1999) Aorto-iliac stenting, determinant of clinical outcome. Eur J Vasc Endovasc Surg 17:351–359
40. Mendelsohn FO, Santos RM, Crowley JJ, et al. (1998) Kissing stents in the aortic bifurcation. Am Heart J 136:600–605
41. Mohamed F, Sarkar B, Timmons G ,Mudawi A, Ashour H, Uberoi R (2002) Outcome of kissing stents for aortoiliac atherosclerotic disease, including effect on non diseased contra-lateral iliac limb. CardioVasc Interv Radiol 25:472–475
42. Uberoi R, Sarkar B, Coleman J, Ashour H, Mudawi A (2002) Duplex followup of aorto-iliac stents. Eur J Vasc Endovasc Surg 23(4):331–335
43. Scheinert D, Schroder M, Balzer JO, et al. (1999) Stent-supported reconstruction for the aortoiliac bifurcation with the kissing balloon technique. Circulation 100 (Suppl II):295–300
44. Mouanoutoua M, Maddikunta R, Allaquaband, et al. (2003) Endovascular intervention of aortoiliac occlusive disease in high risk patient using the kissing stent technique: long term results. Cath Cardiovasc Interv 60:320–326
45. Greiner A, Muhlthaler H, Neuhauser B, et al. (2005) Does stent overlap influence the patency rate of aorto-iliac kissing stents? J Endovasc Ther 12:696–703
46. Upponi SS, Ganeshan AG, Warakaulle DR, Phillips-Hughes J, Boardman P, Uberoi R (2007) Angioseal versus manual compression for haemostasis following peripheral vascular diagnostic and interventional procedures—a randomized controlled trial. Eur J Radiol 61(2):332–334
47. Abando A, Hood D, Weaver F, Katz S (2004) The use of the Angioseal device for femoral artery closure. J Vasc 40(2):287–290
48. Torsello GB, Kasprzak B, Klenk E, Tessarek J, Osada N, Torsello GF (2003) Endovascular suture versus cutdown for endovascular aneurysm repair: a prospective randomized pilot study. J Vasc Surg 38(1):78–82
49. Rosset E, Malikov S, Magnan PE, et al. (2001) Endovascular treatment of occlusive lesion in the distal aorta: midterm results in a series of 31 consecutive patients. Ann Vasc Surg 15:140–147
50. Elkouri S, Hudon G, Demers P, Lembarbe L, Cartier R (1999) Early and long-term results of percutaneous tranluminal angioplasty of the lower abdominal aorta. J Vasc Surg 30:679–692
51. de Vries JPPM, van Den Heuvel DAF, Vos JA, van Den Berg JC, Moll FL (2004) Freedom from secondary interventions to treat stenotic disease after percutaneous transluminal angioplasty of infra-renal aorta: long term results. J Vasc Surg 39:427–31
52. Westcott MA, Bonn J (1998) Comparison of conventional angioplasty with the Palmaz stent in the treatment of abdominal

aortic stenosis from the STAR registry. SCVIR transluminal angioplasty and revascularization. J Vasc Interv Radiol 9(2):225–231

53. Heeney D, Bookstein J, Daniels E, et al. (1983) Transluminal angioplasty of the abdominal aorta: report of 6 cases in women. Radiology 148:81–83
54. Ravimandalam K, Rao VR, Kumar S, et al. (1991) Obstruction of the infrarenal portion of the abdominal aorta: results of treatment with balloon angioplasty. AJR 156(6):1257–1260
55. Von Ingrisch H, Stiegler H, Rath M (1993) Nichtoperative Behandlung von infrarenalen Aortenstenosen durch Katheterdilatation Roentgenpraxis 36:363–367
56. Tegtmeyer CJ, Kellum CD, Kron IL, Mentzer RM (1985) Percutaneous transluminal balloon angioplasty in the region of the aortic bifurcation: the two balloon technique with results and long term follow up study: Radiology 157:661–665
57. Charlebois N, Saint-Georges G, Hudon G (1986) Percuatneous transluminal angioplasty in the lower abdominal aorta. AJR 146:369–371
58. Morag B, Rubinstein Z, Kessler A, et al. (1987) Percutaneous transluminal angioplasty of the distal abdominal aorta and its bifurcation. CardioVasc Interv Radiol 10:129–133
59. Yakes WF, Kumpe DA, Brown SB, et al. (1989) Percutaneous transluminal aortic angioplasty: techniques and results. Radiology 172:965–970
60. Odurny A, Colapinto RF, Sniderman KW, et al. (1989) Percutaneous transluminal angioplasty of abdominal aortic stenosis. CardioVasc Interv Radiol 12:1–6
61. Gross-Fengels W, Steinbrich W, Pichlmaier H, et al. (1990) Percutaneous transluminal angioplasty of the infrarenal abdominal aorta. Radiologe 30:235–341
62. el Ashmaoui A, Do DD, Triller J, et al. (1991) angioplasty of the terminal aorta follow up of 20 patients treated by PTA or PTA with stents. Eur J Radiol 13:113–117
63. Hallisey MJ, Meranze SG, Parker BC, et al. (1994) Percutaneous transluminal angioplasty of the abdominal aorta. J Vasc Interv Radiol 5:679–687
64. Steinmetz OK, McPhail NV, Hajjar GE, et al. (1994) Endarterectomy versus angioplasty in the treatment of localised stenosis of the abdominal aorta. Can J Surg 37:385–390
65. Hedeman Joosten PPhA, Ho GH, Breuking FA Jr, Overtoom TTC, Moll FL (1996) Percutaneous transluminal angioplasty of the infrarenal aorta: initial outcome and long term clinical and angiographic results. Eur J Vasc Endovasc Surg 23:201–206
66. Long AL, Gaux JC, Raynaud AC, et al. (1993) Infrarenal aortic stents: initial clinical experience and angiographic follow up. CardioVasc Interv Radiol 16:203–208
67. Vorwerk D, Gunther RQ, Bohndorf K, Keulers P (1991) Stent placement for failed angioplasty of aortic stenoses: report of two cases. CardioVasc Interv Radiol 14:316–319
68. Therasse E, Cote G, Oliva VL, et al. (2001) Infrarenal aortic stenosis: value of stent placement after percutaneous transluminal angioplasty failure. Radiology 219:655–662
69. Wolf YG, Schatz RA, Knowles HJ, et al. (1993) Initial experience with the Palmaz stent for aortoiliac stenosis. Ann Vasc Surg 7:254–261