Clinical Radiology 69 (2014) e273–e279

Contents lists available at ScienceDirect

Clinical Radiology

journal homepage: www.clinicalradiologyonline.net

Endovascular coil embolization in internal carotid artery bifurcation aneurysms

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ARTICLE INFORMATION

Article history:
Received 25 November 2013
Received in revised form
13 January 2014
Accepted 16 January 2014

AIM: To present the clinical and radiological results of coil embolization in internal carotid artery (ICA) bifurcation aneurysms (BA).

MATERIALS AND METHODS: The records of 65 patients with 66 ICA BA were retrieved from data prospectively accrued between September 1999 and July 2013. Clinical and morphological outcomes of the aneurysms were assessed, including technical aspects of treatment.

RESULTS: The aneurysms under study were directed either superiorly (41/66, 62.1%), anteriorly (24/66, 36.4%), or posteriorly (1/66, 1.5%), and all were devoid of perforators. Aneurysmal necks were situated symmetrically at the terminal ICA (37/66, 56.1%) or slightly deviated to the proximal A1 segment (29/66, 43.9%). The steam-shaped S microcatheter (73.8%) was most commonly used to select the aneurysms, and the single microcatheter technique was most commonly applied (56.1%) to perform coil embolization, followed by balloon remodelling (21.2%), multiple microcatheter (15.1%), and stent-protection (7.6%). Successful aneurysmal occlusion was achieved in 100% of cases, with no procedure-related morbidity or mortality. Imaging performed in the course of follow-up (mean duration 27.3 months) confirmed stable occlusion of most lesions (47/53, 88.7%).

CONCLUSION: Through tailored technical strategies, ICA BA are amenable to safe and effective endovascular coil embolization, with a tendency for stable occlusion long-term.

Introduction

Endovascular coil embolization has been widely used for the treatment of intracranial aneurysms since the International Subarachnoid Aneurysm Trial (ISAT).[1] However, internal carotid artery (ICA) bifurcation aneurysms (BA) were not represented in ISAT, and due to their rarity, very few

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0009-9260/$ – see front matter
http://dx.doi.org/10.1016/j.crad.2014.01.017

reports of ICA BA treated by endovascular methods have been published to date.[2–4] ICA BA develops at the apex of ICA, where high haemodynamic stresses occur, which may be critical in aneurysm formation and growth.[5,6] They tend to present as one of multiple lesions,[3] and perforators sometimes adhere to the neck and dome.[7] The ICA bifurcation is the most common site of cerebral aneurysms in pre-adults, and those afflicted frequently present with subarachnoid haemorrhage.[8,9] In the present study, clinical and radiological results of coil embolization in 65 patients with 66 ICA BA were evaluated, including technical aspects of endovascular treatment.

Materials and methods

Study population

Between September 1999 and July 2013, 2745 patients with 3430 intracranial aneurysms were treated by endovascular methods at Seoul National University Hospital. Among them, 65 patients with 66 ICA BA (1.9%) were consecutively enrolled, including one patient with mirror aneurysms. ICA BA were defined as those lesions involving the apex of ICA bifurcation, where it divides into the A1 segment of the anterior cerebral artery (ACA) and the M1 segment of the middle cerebral artery (MCA). Aneurysms arising purely from the proximal A1 or M1 segments (true A1 or M1 aneurysms) were excluded, as were duplicated MCA aneurysms and dissecting or fusiform aneurysms. Informed consent was obtained from each patient after careful consultation (evaluating risks, benefits, and alternatives such as aneurysm clipping) as part of a multidisciplinary decision-making process involving both neurosurgical and neurointerventional teams. This study was conducted with the approval of the Institutional Review Board.

Aneurysm characteristics

All patients underwent routine and rotational cerebral angiography, with three-dimensional (3D) images reconstructed using a biplane angiographic unit (Integris Allura, Philips Medical System, Best, The Netherlands). The characteristics of each aneurysm, including location, related branches or perforators, overall size, neck diameter, and depth-to-neck ratio were estimated. Geometric features, such as predominance of neck position and dome projection, were also evaluated. Positioning of aneurysmal necks was evaluated by 3D digital subtraction angiography (DSA) and classified as follows: "symmetrical" in which the centre of the aneurysmal neck was located at the midline the of terminal ICA; "A1 predominance" in which the centre of the aneurysmal neck deviated towards the ACA; and "M1 predominance" in which the centre of the aneurysmal neck deviated towards the MCA (Fig 1a–c). The degree of aneurysmal neck deviation was determined by measuring the distance between the midpoints of the terminal ICA aneurysmal neck.[10] Aneurysmal projection (i.e., orientation of the aneurysmal dome relative to the axis of the distal ICA) was evaluated on lateral 3D digital subtraction angiography (DSA) and designated anterior, superior, or posterior (Fig 1d–f).

Endovascular procedure

All the procedures were performed under general anaesthesia. Patients with unruptured aneurysms were given single (clopidogrel) or dual (clopidogrel and aspirin) antiplatelet medication in advance, depending on results of VerifyNow P2Y12 clopidogrel-resistance assays. Dual or triple antiplatelet therapy was administered if stent protection was anticipated. Cilostazol was added in patients showing poor response to clopidogrel. An initial bolus of heparin (3000 IU) was given after placement of a femoral arterial sheath, and heparin was later infused in an hourly booster dose (1000 IU/h), with monitoring of the activated clotting time. With ruptured aneurysms, systemic heparinization was deferred until adequate coil protection was achieved. An oral antiplatelet agent was continued after the procedure in instances of coil protrusion, composite atherosclerotic narrowing, or stent placement. Shapes of microcatheters used to select the aneurysms were based on aneurysmal direction and parent arterial course.[11] When failing to create a stable coil frame with a single microcatheter, supplemental manoeuvres were tried, such as multiple microcatheter use, balloon remodelling, or stent-assisted technique.

Completion angiography, entailing postero-anterior, lateral, and working projection images, was performed to assess the status of embolization. Immediate angiographic results were categorized as follows: "completion occlusion" in which no residual filling of the aneurysm was present; "residual neck" in which limited residual filling of the aneurysmal neck (not body or dome) was present; and "residual aneurysm" in which residual filling of the aneurysmal body or dome was present.[12]

Clinical and radiological follow-up

Clinical outcomes were scored using the modified Rankin scale (mRS), which was applied throughout the hospitalization period and at the last available clinical follow-up. In patients with unruptured aneurysms, magnetic resonance angiography (MRA) with 3D reconstruction and/or plain radiography was recommended at 6, 12, 24, and 36 months after coil embolization. Plain radiography was also advised at 1 and 3 months post-embolization in patients presenting with haemorrhage. If recanalization was suspected by non-invasive tests (i.e., MRA or plain radiography), conventional angiography was suggested so that further treatment could be given as needed. Anatomical outcomes on follow-up were categorized as follows: stable occlusion (no interval change since procedure or progressive thrombosis within aneurysm); minor recanalization (progressive filling limited to neck of aneurysm); and major recanalization (filling of aneurysmal sac). Repeat embolization was advocated for patients showing major recanalization.[11]