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Research article

Peri-aortic fluid after surgery on the ascending aorta: Worrisome indicator of complications or innocent postoperative finding?

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ABSTRACT

Objective: The Bentall procedure is associated with several complications often accompanied by accumulation of fluid around the aortic graft. CT is the imaging modality of choice to detect these complications. Since these early complications are, however, not easily distinguished from physiological postoperative changes, our aim was to compare the appearance and amount of peri-aortic fluid on early CT scans following Bentall procedures with either an uncomplicated or a complicated course and follow-up.

Methods: Ninety-four scans performed within 3 months of a Bentall procedure were retrospectively included. Patients were divided into either the uncomplicated or the complicated group based on occurrence of Bentall-related complications or death up until 1-year after surgery. Diffuse fluid ("stranding") was distinguished from organized, more clearly delineated fluid collections such as haematomas, and was graded both subjectively and quantitatively.

Results: Forty-seven patients were assigned to each group. Stranding was found on most of the scans, both in the uncomplicated (7.7 ± 3.9 mm, range 0–17 mm) and complicated (6.9 ± 5.5 mm, range 0–19 mm) groups ($p = 0.32$). There were, however, significantly more fluid collections (6 vs. 28; $p < 0.001$), particularly haematomas (1 vs. 17; $p < 0.001$), in the complicated group. When looking at isolated stranding, there was still no significant difference between the two groups (7.8 ± 3.6 mm vs. 9.2 ± 3.7 mm; $p = 0.22$).

Conclusion: Isolated stranding of up to 17 mm is a common finding on postoperative CT within three months of a Bentall procedure, regardless of the occurrence of complications during the procedure or within a 1-year follow-up. Fluid collections are more worrisome indicators of complications that may require closer monitoring.

1. Introduction

The so-called Bentall procedure consists of the replacement of the aortic valve and ascending aorta in a single operation [1]. The most common pathologies that require this kind of intervention are type A aortic dissections and large ascending aortic aneurysms with associated aortic valve stenosis or insufficiency.

This major intervention may lead to both peri- and post-procedural complications [2,3], of which some of the most fearsome and potentially fatal are infection of the aortic prosthesis and endocarditis. The imaging modality of choice to depict their occurrence is CT, which is also preferred for routine follow-up examinations.

Due to the extensive structural changes occurring during surgery, certain postoperative alterations can be expected, such as the presence of fluid and stranding in the adipose and soft tissue surrounding the prosthesis, especially in the earliest time period following the procedure. However, infections may show an analogous radiological appearance, resulting in diagnostic dilemmas. Moreover, in most cases the interpretation of the images cannot be guided by the patients' clinical information/presentation because post-operative CT scans are performed as routine follow-up in asymptomatic patients and, furthermore, complications such as endocarditis often present with no or generic symptoms. It is therefore of paramount importance for the radiologist to be familiar with the normal aspects and their physiological change as time progresses in order to be able to distinguish these from complications that need to be closely observed, treated with

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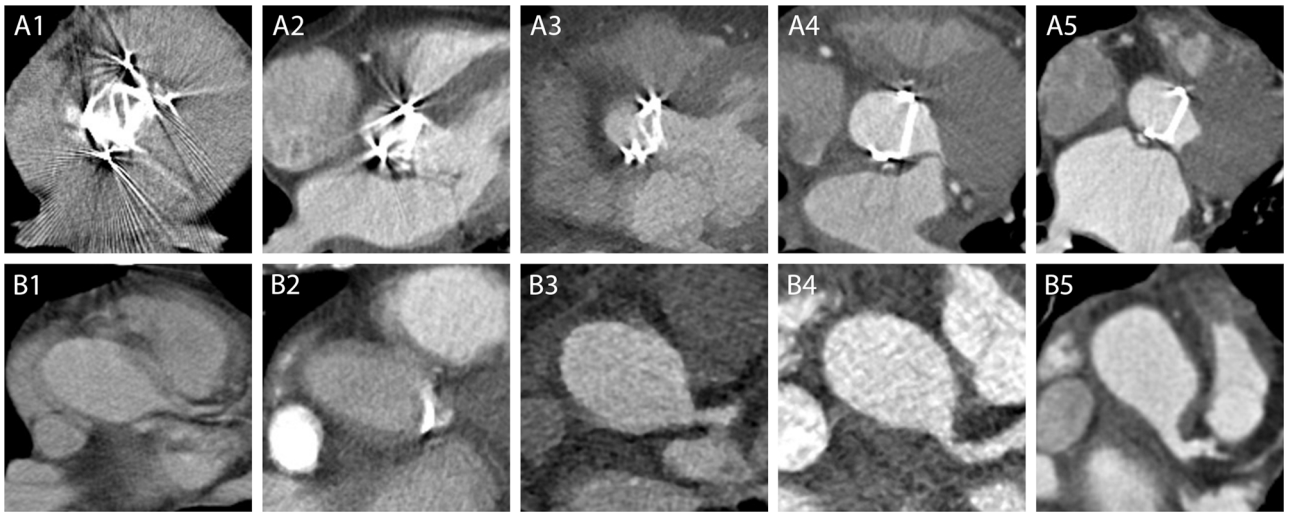

Fig. 1. Rows **A** and **B**: Representative examples for the different CT quality grades, from poor (**A1**, **B1**) to excellent (**A5**, **B5**). The examples show axial images of different patients at the level of two of the most sensitive locations for grading purposes: the aortic valve prosthesis (**A1-5**) with the beam hardening and scattering artefacts, and left coronary artery ostium (**B1-5**) with motion artefacts.

medical therapy or even a new intervention. Unfortunately, literature regarding normal postoperative CT features after Bentall procedures and their change over time is still limited.

To determine a normal reference, we have retrospectively assessed the appearance and amount of fluid surrounding the composite graft of the aortic valve and ascending aorta on CT scans performed within the first three months following both uncomplicated procedures and procedures with a complicated course or follow-up.

2. Material and methods

2.1. Study population

In this single-center retrospective cohort study, for which a waiver was received from the local Medical Ethics Committee, patients were selected from a large database comprising 391 Bentall procedures performed in 388 patients in the period between August 2000 and February 2015. Through a search in their electronic files, 206 patients who had undergone at least one CT scan after the procedure were identified. In total, 417 postoperative scans were performed in these patients. Since most of the early complications of a Bentall procedure occur in the first three months [4–6] and this is when a reference of the spectrum of normal findings is most crucial, only patients who had undergone a CT scan during this period were selected for the purpose of this study. For each patient only the first scan performed within these three months was included in the analysis.

2.2. Complicated versus uncomplicated procedures

To determine the normal appearance and amount of peri-aortic fluid after a Bentall procedure, healthy patients with an uncomplicated follow-up had to be distinguished from patients who had experienced complications during or after the procedure. To accomplish this, all patient files were carefully analyzed and evaluated for strict criteria which had been postulated beforehand, in order to determine whether the procedure and follow-up had been uneventful: (a) the surgical report of the Bentall procedure itself mentioned no procedural complications, (b) the patient was discharged within 14 days of surgery, and was not reoperated upon (e.g. for bleeding or tamponade, infection, sternal dehiscence or other early complications) during this period, (c) the patient was neither readmitted for Bentall-related complications nor deceased within one year of the procedure, and (d) the CT-scan was not performed for suspicion of Bentall-related complications, but rather only as routine follow-up.

Patients who were reoperated upon were further divided based on whether the CT scan had been performed before or after the second procedure. A separate analysis was performed for the first subgroup but not for the second, due to the impossibility to ascribe the findings to either one of the operations. Unless stated otherwise, time was calculated in relation to the first operation.

2.3. CT scan assessment

All selected scans performed at our institution or an affiliated one, of which the images were readily available at our institution's PACS, were then retrieved and reassessed on a dedicated multimodality workstation (iSite Enterprise 4.1, Philips Healthcare, the Netherlands) by a blinded observer with over 4 years of experience in cardiovascular imaging. Firstly, several technical parameters of the scans were evaluated, including the number of detectors of the scanner, the smallest reconstruction slice thickness with vascular or soft tissue kernel, and whether the scan had been gated electrocardiographically. Subsequently, the scans were systematically reviewed and scored with regard to technical image quality and the appearance and amount of fluid surrounding the ascending aorta using a predefined reference sheet. The observer had not been involved in the initial selection of scans and was blinded to the reported CT scan results, the request form and any other clinical data.

Overall scan quality was graded on a 5-point scale as 1. poor, 2. moderate, 3. reasonable, 4. good or 5. excellent, based mostly upon the presence of motion artefacts at the level of the ostium of the coronary arteries and ascending aorta, as well as on the extent of beam hardening and scatter artefacts due to any metallic components of the aortic valve prostheses. Key images exemplifying each quality grade are provided in Fig. 1.

Then, the periaortic fluid was categorized as stranding or a fluid collection based on its appearance. Stranding was defined as an encircling area of increased attenuation of the adipose tissue along the external edge of the aortic lumen, with ill-defined borders and an infiltrating appearance. Fluid collections were distinguished from stranding by their clearer, more regular delineation and their often-incomplete surrounding of the aortic circumference (Fig. 2).

Afterwards, we evaluated the amount of stranding, both subjectively and objectively. The overall quantity of the stranding extending in the adipose tissue surrounding the aortic prosthesis was subjectively graded with a 5-point scale as slight, mild, moderate or