Evolution of post-traumatic aortic aneurysm in the subacute phase: magnetic resonance imaging follow-up as a support of the surgical timing

Rossella Fattori*, Francesca Celletti, Benedetta Descovich, Gabriella Napoli, Paola Bertaccini, Roberto Galli, Giampaolo Gavelli, Angelo Pierangeli

Institute of Radiology and Cardiac Surgery, University Hospital S. Orsola, Bologna, Italy

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Abstract

Objectives: A recent surgical series documented that in traumatic aortic rupture (TAR) a surgical repair postponed to the treatment of associated lesions reduced operative and overall mortality. Nevertheless some isolated cases may develop to free rupture. Until now, no imaging follow-up studies of post-traumatic aortic lesions have been reported in the early stage. The aim of this study is to analyze the behaviour of traumatic aortic ruptures in the subacute phase, in order to detect the morphological characteristics of unstable post-traumatic aneurysms.

Methods: Twenty-five consecutive patients affected by traumatic aortic rupture (one intimal hemorrhage, 19 partial lesions and five circumferential lesions) were admitted to the department of cardiac surgery. Magnetic resonance imaging (MRI) was the imaging method used to confirm the diagnosis. No one was operated on during the acute phase. All patients were treated with β-blockers and vasodilators as well as limited fluid administration. Delayed surgery was carried out in 18 patients at 243 days (±127), after the resolution of associated lesions. A scheduled MRI follow-up was performed at 7, 15 and 30 days and immediately before the operation. The parameters examined were increase of post-traumatic aneurysm, increase of periaortic hematoma and modification of the thoracic associated lesions.

Results: At 30 days a 3.0–3.7 mm median increase of the aneurysm was observed, while in the subsequent period the lesions became substantially stable, resulting in a 4.4 ± 3.6 mm increment at the end of the follow-up. The circumferential lesions presented a higher increment with respect to the partial lesions. In three cases an augmentation of 6, 7 and 12 mm was detected and surgical repair was anticipated. In 13 cases a periadventitial hematoma surrounding the aortic aneurysm decreased through the time. One case of intimal hemorrhage healed spontaneously, with no aneurysm formation. Thoracic associated lesions (pleural and pericardial effusions, rib fractures, lung focal contusions and two cases of ARDS) resolved at 30–60 days.

Conclusions: Despite common knowledge, considering TAR highly evolutive in the acute and subacute phase, this study demonstrated that this pathological entity is relatively stable if a proper pharmacological treatment is administrated. MRI follow-up is recommended in order to detect isolated cases of unstable aneurysm.

Keywords: Aorta; Magnetic resonance imaging; Surgery

1. Introduction

Traumatic aortic rupture (TAR) is conventionally considered a surgical emergency as far as its natural history is concerned. This statement is primarily based on autopsy series [1,2], reporting a very high mortality at the scene of the accident and in the subsequent few hours in the cases who survived the traumatic impact. Nevertheless, the critical combination of a cardiovascular intervention in a severely injured patient led to an operative mortality of 15% to 45-50%, representing the highest rates in cardiac surgery. New strategies in the surgical timing of TAR have to be considered, in the attempt to modify its negative prognosis. An emergent concept in the recent literature is to delay the surgical repair of TAR when the other life-threatening injuries stabilize, submitting these patients to a pharmacological protocol consisting of antihypertensive therapy...
and limited fluid administration during the preoperative time. Several series in the last years [3–6] report an overall reduction of mortality and morbidity in comparison with the emergency surgery, with few isolated cases of death due to aortic rupture before surgery. However, considering that no imaging modalities were used in previous follow-up reports, no data are available up to now to identify the possible evolutive aortic lesions.

The aim of this study was to analyze by magnetic resonance imaging (MRI) the behaviour of traumatic aortic ruptures in the subacute phase, in order to detect the morphological characteristics of unstable post-traumatic aneurysms. We also evaluated the evolution of the thoracic associated lesions in order to assure the optimal respiratory condition in view of the operation.

2. Methods

From January 93 to August 97, 25 patients affected by acute TAR were admitted to the department of cardiac surgery being referred to hospital at various times after the accident ranging from 4 h to 12 days (average 14 h). According to the definitions reported by Kirklin [7] and by Finkelman [8], a traumatic aortic lesion is defined as acute when is seen within 14 days of the accident, while it is defined as chronic after 3 months following the accident. We considered the period between the acute and the chronic phase the subacute phase. The cause of the trauma was a car accident in 20 cases and a fall from height in 5 cases. The injury severity score of the patients at the time of admission was 29.2. Head trauma was present in 12 cases, bone fractures in 21 cases and thoracic cage trauma was present in 19 cases, of which 15 were in assisted ventilation. The suspicion of the lesion arose from positive chest X-ray (seven cases) or CT (18 cases) performed in the community hospitals or in the emergency department. MRI (0.5 Tesla MRI Max Plus, General Electric Medical Systems) was the imaging modality used in the acute phase to confirm the diagnosis and to assess rupture anatomic details, such as the type of lesion (partial or circumferential), diameter of post-traumatic aneurysm and the presence of periaortic hematoma. A spin-echo sequence was performed in the axial and/or sagittal plane in a median time of 15.8 – 5.6 min. On MRI images we also evaluated the thoracic associated lesions, such as ribs fractures (15 patients), pleural (18 patients), mediastinal (seven patients) and pericardic (three patients) effusion, lung contusions (six patients) and pulmonary edema, as in the case of acute distress respiratory syndrome (two patients). All the aortic lesions were localized at the isthmic aorta, in one case extended to the left subclavian artery. One patient had evidence of intimal hemorrhage with no signs of aortic wall laceration. Nineteen patients had a partial lesion, in 16 cases localized at the anterior wall and in three cases at the posterior wall. Five patients presented a circumferential lesion, or rather a lesion extended to the anterior and to the posterior wall. In 13 cases a periaortic effusion was also evident.

No one was operated in the acute phase. In the acute phase all the patients were treated with β-blockers (propranolol i.v.) and vasodilators (nitroprussiate or nitrates) as well as being monitored for fluid administration in order to obtain a systolic arterial pressure inferior to 120 mmHg and a heart rate inferior to 60 beats/min. Oral antihypertensive therapy was then continued for the whole period before operation. Before surgery MRI was performed at 7, 15 and 30 days and immediately before the operation in order to monitor the evolution of post-traumatic aneurysm, periaortic hematoma, mediastinal hematoma, and thoracic associated lesions.

3. Results

One patient with a partial aortic lesion, pelvis fracture and thoracic trauma died 6 days after the accident from a massive pulmonary embolism. The intimal hemorrhage healed spontaneously without aneurysm formation. Conservative treatment was elected in one case of small, partial tear giving a diverticular aneurysm of 2.5 cm of diameter, unchanged over 2 years of follow-up. Eighteen patients were operated at 243 days (±127, ranging from 15 to 510 days) when the other life-threatening injuries were stabilized. The last four patients are scheduled for surgery. Up to now operative mortality has been absent. In the majority of cases the thoracic lesions, such as lung focal contusions, pleural and mediastinal effusions were resolved in 15–30 days with the only exception of a patient presenting acute distress respiratory syndrome requiring prolonged assisted ventilation.

At 30 days, a 3 mm (±3.7 mm, ranging from 0 to 13 mm) median increase of the aneurysm was detected in 23 cases. The partial lesions presented a median increase
inferior to the circumferential lesions (1.8–2.2 mm vs. 5.9–5.2 mm \( P < 0.04 \)). The maximum increment was mainly observed at the first 7 days, while in the subsequent period the lesion became substantially stable, resulting in a median increment of 4.4–3.6 mm at the end of follow-up (3.4 mm the partial lesion, 6 mm the circumferential lesion) (Fig. 1). In five cases the periaortic hematoma increased in the first 7 days but showed a progressive reduction at the subsequent MRI. In the remaining eight cases the hematoma were completely reabsorbed in 15–30 days.

In three cases an increment of 6, 7 and 12 mm of the aneurysm was observed. One patient presented a large circumferential lesion with a posterior aneurysm of 4 cm, periaortic effusion and invagination of the intimal flap (Fig. 2A). In the acute phase he was treated with \( \beta \)-blockers and vasodilators. Due to the severe lung bones and pelvis fractures, the patient was transferred to the orthopedic department and antihypertensive therapy was inadvertently stopped. At 30-days MRI follow-up an enlargement of 12 mm was detected along with an increase of periaortic effusion (Fig. 2B), and this was considered an indication for early surgical repair. In the second case, a partial lesion with a periaortic hematoma extending along the posterior wall of the descending aorta (Fig. 3A), an increment of 7 mm of the aortic lesion and of the periaortic hematoma (Fig. 3B) was detected at the first MRI follow-up study. MRI documented also the resolution of lung contusions, the only associated lesions presented, so that the operation could be successfully performed. The third case was a circumferential lesion extended posteriorly to the left subclavian artery, in which the pharmacological control of the blood pressure was difficult in the acute phase, despite \( \beta \)-blockers, \( \alpha \)-blockers and vasodilators. At the first MRI follow-up an increment of 6 mm of the lesion was detected. Considering the severe head and thoracic associated lesions and the necessity to perform extracorporeal circulation in that type of lesion, the operation was delayed. The patient was then submitted to a strict monitoring of hemodynamic parameters and of the lesion by subsequent MRI; a better control of the systemic pressure was obtained and no more increments of the aneurysm was detected at 15 and 30 days.

4. Discussion

Among lethal traumatic lesions, aortic rupture is secondary only to head trauma: 25% of deaths resulting from motor vehicle accidents are associated with TAR, accounting for 8000 victims/year in the US [9,10]. Airbags and seatbelts do...
not protect against this type of impact. Such injuries can be expected to gain prominence in road traffic injury statistics, since the frequency of lethal injuries in head-on collisions is lowered by the mandatory use of restraints, which protect the victim from thoracic and head lesions but not from the mechanism producing aortic rupture [11,12].

It is commonplace to consider traumatic aortic rupture a lesion highly evolutive through free rupture. This concept is primarily based on the historical study, by Parmley in 1958 [1], who reported autopsy findings in 296 cases of non-penetrating TAR. This article has been referred to in every subsequent report on this topic and has influenced the general opinion over the next 40 years. Remarkably, Parmley’s analysis estimated that 85% of the victims died on the scene from free aortic rupture; of those who survived at least for 1 hour, 30% died within 6 hours, 49% within 24 h and 90% within 4 months. The impressive negative natural history of TAR victims gave rise to the statement that this lesion requires immediate surgical repair, with absolute priority over any other associated injury. Despite progress in cardiac surgery and anesthesiology during the last few years, the peri- and postoperative mortality in TAR has not altered perceptibly [13–15]. This finding stimulated the need for new strategies along with a critical review of Parmley’s data. The 1958 Armed Forces Institute of Pathology series is a cohort which probably does not apply to the current clinical reality. A clear relation between free aorta rupture and death is not reported, nor how much the other potentially fatal injuries, occurring in more than half of the patients, actually contribute to death. Due to the complexity of polytraumatized patients, conclusions ruled out from autopsy series cannot strictly be applied to the surgical setting. To this purpose, Pate et al. [16] analyzed 15 years of English-language literature, and their experience in 112 patients, in the search for evidence of the risk of aortic free hemorrhage in patients affected by acute TAR in the interval between diagnosis and delayed surgical repair. Of the 492 patients in reports specifying the cause of death, 22 (4.5%) died of aortic rupture, mostly presenting with hemodynamic instability and actively bleeding into the pleural space on arrival. In the Pate’s group, only two (4.3%) developed fatal rupture of the hematoma before aortic surgery within 4 h of arrival; in both cases arterial hypertension (160 and 180 mm Hg) was documented prior to aortic rupture. Several reports in the recent literature reported a decreased mortality, both spontaneous and operative, by managing these patients under a formal protocol, consisting of limited fluid administration and antihypertensive therapy. Delayed aortic repair was then performed after treatment of the other life-threatening lesions. Patients must be admitted to an intensive care unit with continuous monitoring of ECG, arterial and central venous pressure, renal function and peripheral metabolism. Monitoring of respiratory function is fundamental in polytraumatized patients [6]. Respiratory insufficiency, due to central nervous system injury, pulmonary contusion and pleural effusion, is the leading cause of death in these patients. The comprehensive evaluation of the thoracic compartment provided by MRI represents a helpful contribution in stratifying the risk of emergency or delayed surgical repair. In our experience the major thoracic associated lesions, such as lung focal contusions and pulmonary edema, were resolved in 15 days (Fig. 4A,B), with the only exception of a case of severe acute respiratory distress syndrome. The characteristic of MRI to detect the hematic content of a lesion by its high signal intensity is widely useful in a polytraumatized patient. This might be applicable to every traumatic lesion, such as head and abdominal lesion, with a short addition of time.

Traumatic aortic rupture has to be considered a potentially evolving lesion in which free rupture may unpredictably occur [8]. Up to now, no imaging follow-up study has been performed, and nothing is known about the anatomic characteristics and the growing rate of the aortic lesion in the subacute phase. MRI demonstrated a high accuracy in the detection of TAR, in comparison with the other standard used imaging modalities [17]. The multiplanar, high definition evaluation of the thoracic aorta can depict morphological details about the aortic wall lesion and periaortic structures, useful to stratify the risk of delayed or emergency surgical repair. The discrimination between partial and cir-
References


Appendix A. Conference discussion

Dr U. Althaus (Bern, Switzerland). In our institution, for the past 12 years, we follow the same strategy of delayed surgery; and we did not lose any patient while waiting for surgery. But I think there are some conditions which should prompt us to perform immediate aortic repair, and that is increasing hemothorax or an important coarctation syndrome due to a hematoma which is under high pressure. I think these conditions have to be regarded as important clinical signs indicating an imminent risk of free rupture and in this situation immediate surgery should be performed. Could you agree with this attitude?

Dr Fattori: I absolutely agree with you. In our series, none of these patients had recurrent hematoma, hemothorax or a pseudoaneurysm but I think in these cases it is very correct to operate early.

Dr T. Pezzella (Worcester, MA, USA): We have had an interest in this lesion for almost 20 years now, and we advocated an approach similar to yours in selected patients. However, the evolution of the procedure is such that patients who could tolerate surgery would be operated on early, and only in selected cases would surgery be delayed. Your approach is rather intriguing. The problem I see is that the use of MRI in most centers is either unavailable or very difficult to do. Have you used the CT or even TEE to help you in better defining a classification that could help us in not only the unstable patients but in the stable patient who otherwise would have urgent or emergency surgery?

Dr Fattori: We use MRI to confirm the diagnosis done with a CT scan in our case usually coming from the community hospital. The previous strategy in these cases was to do angiography. We substituted angiography with MRI and we did not find particular difficulties in performing MRI, even in acute patients.

Dr H. Bors (Munich, Germany): I have one comment and one question. The comment is you said that the blood pressure should be around 120. We do not agree with that. I think many of these patients are young and the pressure should be lower, as would be compatible with a decent urine output, which means that usually the pressure is between 90 and 100 systolic. Obviously the MRI is a very good tool for demonstrating these lesions, but I think for follow-up you might also use intravascular ultrasound. Does that play any role in your experience? It is very easy to do and it delineates the aneurysm or the lesion very well.
Dr Fattori: I agree about the low blood pressure. We indicate 120 because, especially in the acute phase, it may be difficult to achieve an optimal systolic pressure in patients in shock, or hemorrhagic patients. But I agree that it may be slower than 120. In our cases often it is so. Regarding echo TE, I do not agree that it is the ideal technique in traumatic aortic rupture, for two reasons especially. The first is that it is better to have a comprehensive overview of the mediastinal problems. MRI has a wide field of view and you can accumulate information about mediastinal effusion, pleural effusion, lung contusion, important information for prognosis. By echo TE you cannot have the same information. And the second reason is that in echo TE, the aortic arch, that sometimes is involved with the aortic lesion, has various blind spots in which you cannot be sure of your information. This is the reason why we prefer MRI.

Dr G. Rizzoli (Padua, Italy): You projected the slide of the instantaneous hazard of death of these patients. I would like to know the average or median distance from the moment of the accident of the patients of your series.

Dr Fattori: The median time from the accident in our cases is ranging from 6 h to several days. They are transferred from another hospital. In some cases there is even 3 or 4 days of delay, because the diagnosis may be difficult sometimes.

Dr Rizzoli: Well, I think that I would be very confident to leave a patient without an operation if I see him after 3 days, but I would not be so confident if I see him after 6 h. I mean is there any special care you use to be on the safe side in the first hours.

Dr Fattori (Bologna, Italy): All the patients have the same protocol. We monitor the patient in the care unit and we do not do anything difference with regard to the time of arrival.