Midterm experience with modified Cabrol procedure: Safe and durable for complex aortic root replacement

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Objective: To evaluate the early and late outcomes of the modified Cabrol technique as a method of coronary reimplantation during complex composite graft replacement of the ascending aorta.

Methods: Between 1995 and 2012, 348 patients (mean age, 56 ± 14 years; 283 males and 65 females) underwent composite graft replacement of the ascending aorta, 40 of whom (mean age, 60 ± 12 years; 35 males and 5 females) had one or both coronary ostia reimplanted using a modified Cabrol technique with an 8- to 10-mm Dacron interposition graft. The mean clinical and radiologic (computed tomographic scan) postoperative follow-up was 39 months (range, 1-171 months), via our aortic database, patient interviews, and Social Security Death Index.

Results: Cabrol reimplantation was necessitated by reoperations with anatomically fixed coronary ostia (n = 16, 40%), severely displaced coronary arteries (n = 15, 37.5%), button calcification (n = 4, 10%), coronary anomalies (n = 3, 7.5%), and coronary aneurysm (n = 2, 5%). Of the operations, 20% (8 patients) were urgent interventions. Early mortality was 3 (7.5%) of 40, none related to the Dacron interposition graft. Total late mortality was 16.2%, also not related to the coronary graft. Actuarial survivals were 0.88 ± 0.05, 0.79 ± 0.07, and 0.73 ± 0.08 at 1, 3, and 6 years, respectively. Radiologic follow-up was available for 31 (83.8%) of the surviving patients and revealed that the interposition graft was widely patent in all.

Conclusions: The modified Cabrol technique using a Dacron interposition graft showed good survival rates and excellent durability over time, confirmed radiographically. These data confirm that it is appropriate to use the Cabrol technique when technical complexity prevents bringing coronary buttons to the main aortic graft. (J Thorac Cardiovasc Surg 2014;147:1233-9)

Current surgical therapy for patients with aortic root aneurysms or dissections of the ascending aorta involves either composite graft replacement of the aorta or a valve-sparing aortic replacement.[1] Either approach requires meticulous reimplantation of the ostia of coronary arteries into the newly implanted aortic graft. Over the years, there has been debate regarding the optimal strategy for reimplanting the coronary arteries into the graft,[2] since the first report of Wheat et al[3] of a successful replacement of the ascending aorta and aortic valve. The procedure originally described by Bentall and De Bono[4] in 1968 (later known as the ''classic Bentall procedure'') involved reimplantation of the coronary ostia into the aortic graft. In 1981, Carbol described an alternative technique for restoring blood flow to the coronary arteries using a ''moustache-shaped'' interposition graft.[5] This procedure later became known as the ''classic Cabrol technique.'' Concerns over patency plagued this procedure. More recently, a modification of the original Bentall technique, namely the ''button technique'' of Kouchoukos et al,[6] which requires mobilization of the coronary ostia and formation of coronary ''buttons,'' has gained popularity and is considered the gold standard for aortic root replacement operations.

Although initially reported with excellent results by Cabrol himself,[7] the Cabrol technique over the years became nearly obsolete because of reports of stenosis, thrombosis, and occlusion of the interposition graft.[2,8-12] In 2003, Gelsomino et al[2] reported a nonnegligible incidence of early and long-term complications and recommended against using this procedure. The classic Cabrol reimplantation technique uses one relatively long interposition graft, one end of which is anastomosed to the right and the other end to the left coronary ostium, with a further side-to-side anastomosis with the aortic graft.[5] However, in recent years, many modifications of the Cabrol technique have been described, most of which are summarized in an excellent report by Kourliouros et al.[13] One of the Cabrol modifications that has gained popularity is the technique of using 2 short separate interposition grafts, which are directly implanted into the aortic graft. The first such experience was described by Piehler and Pluth,[14] who used a short Gore-Tex graft for reimplanting the left coronary artery, while the right coronary artery was reimplanted directly into the aortic graft with the inclusion technique. However, there is controversy

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Abbreviations and Acronyms
CT = computed tomography
DHCA = deep hypothermic circulatory arrest

as to whether this technique should be referred to as the modification of the Cabrol or the Bentall procedure. Mills et al[15] and Kourliouros et al[13] consider this to be a modification of the Cabrol technique. At the same time, Hirasawa et al[16] and Maureira et al[17] tend to name it a modification of the Bentall procedure. It seems that relative length of the interposition grafts is the decisive criterion, with longer grafts being referred to as Cabrol modifications and shorter ones as Bentall modifications. For simplicity, in this report, all coronary reimplantation techniques with a separate interposition graft will be referred to as "modified Cabrol technique."

At our institution, we use the classic Cabrol technique and its modifications on rare and complex occasions and believe that it is a useful technique in the arsenal of a cardiothoracic surgeon. We find this option helpful when the contemporary button technique cannot be used, usually because of fixation of the coronary ostia as the result of reoperation or inflammation. Thus, the aim of this study is to evaluate the early and long-term outcomes associated with the Cabrol technique, with specific attention to the fate of the coronary interposition graft on radiologic follow-up.

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METHODS

Patient Profile

During a 17-year period between January 1995 and October 2012, 348 patients (mean age, 56 ± 14 years; 283 males and 65 females) underwent composite graft replacement of the ascending aorta at Yale–New Haven Hospital (New Haven, Conn). Forty (11.5%) of these patients had one or both coronary ostia reimplanted using a modified Cabrol technique with an 8- to 10-mm Dacron interposition graft. In one case, a saphenous vein graft was used instead. The remaining 308 patients underwent a conventional button reimplantation technique. The frequency of composite graft replacement procedures increased over the years, as did the frequency of using the Cabrol technique (1995-2005, 7; 2006-2012, 33). This report will focus on the 40 Cabrol patients.

The detailed preoperative characteristics of the patients operated on by the modified Cabrol technique are presented in Table 1, and are compared with the preoperative characteristics of the patients operated on by the conventional coronary button reimplantation technique. The Cabrol patient group had a significantly higher percentage of redo cardiac procedures and emergency interventions. The prevalence of diabetes was significantly greater among the Cabrol patients, whereas the prevalence of hypertension and hyperlipidemia was higher in the conventional button technique group.

Sixteen of the Cabrol patients (40%) had undergone at least one previous open-heart procedure, of which 11 were related to the aorta or aortic valve, 3 were coronary artery bypass operations, 1 was a mitral valve replacement, and 1 was a closure of a ventricular septal defect. One patient had 3 previous cardiac operations for congenital defects. The indications for surgery in patients who were operated on using the Cabrol technique were the following: annuloaortic ectasia (n = 24), chronic dissection (n = 8), acute dissection (n = 5), and reoperation for aortic stenosis (n = 3; 2 of these were cases of aortic valve stenosis of previously implanted homografts, and 1 was a case of isolated aortic stenosis with a normal-sized aorta).

Operative Technique

All operations were performed through a standard median sternotomy with the use of cardiopulmonary bypass. Operative data are shown in Table 2. The femoral artery was used in 34 (85%) cases and was the preferred arterial cannulation site. Our approach and technique of femoral cannulation was reported previously.[18] Other cannulation sites included the aortic arch (3 patients), the axillary artery (2 patients), and the innominate artery (1 patient). Venous return was via the right atrial appendage in 37 patients and the femoral vein in 3 patients. Patients were cooled systemically to 24°C to 26°C, unless we anticipated the need for circulatory arrest, in which case cooling to a level of deep hypothermia was performed (18°C-19°C). Straight deep hypothermic circulatory arrest (DHCA) was used as the sole means of cerebral protection in this group of patients, according to the technique described earlier.[19,20] No additional cerebral perfusion adjuncts (antegrade or retrograde cerebral perfusion) were used. DHCA was necessitated in cases of total or partial replacement of the aortic arch and in complex reoperative cases when an open distal anastomosis of the ascending aorta was safer to perform. Myocardial protection was achieved by infusing crystalloid cardioplegia through the coronary sinus in a retrograde manner.

Replacement of the aortic valve, aortic root, and ascending aorta was performed using a valved conduit. In 25 patients (62.5%), a prefabricated St Jude mechanical valved conduit was used (St Jude Medical, St Paul, Minn). Bioprosthetic aortic valves were used in 13 patients (32.5%). In 10 patients, the tissue valve conduit was created in the operating room by hand sewing a Carpentier-Edwards bioprosthetic aortic valve (Carpentier-Edwards, Irvine, Calif) into a Hemashield graft (Boston Scientific, Natick, Mass). In 2 patients, a Medtronic Freestyle Aortic Root Bioprosthesis (Medtronic, Minneapolis, Minn) was used. One patient required an isolated aortic valve replacement, which was performed using a Carpentier-Edwards tissue valve. In 2 cases, we were able to preserve the prosthetic aortic valves, which were implanted during previous cardiac procedures.

In cases when direct reimplantation of one or both coronary ostia into the neoaorta was not feasible, reimplantation using the modified Cabrol technique was implemented. The indications for using the Cabrol reimplantation technique were the following: reoperations with anatomically fixed coronary ostia (n = 16, 40%), severely displaced coronary arteries (n = 15, 37.5%), severe coronary button calcification (n = 4, 10%), coronary anomalies (n = 3, 7.5%), and ostial coronary aneurysm (n = 2, 5%).

We used 3 different modifications of the classic Cabrol reimplantation technique, which were all slightly different from the originally proposed method:

1. Both right and left coronary ostia reimplanted using one long interposition graft (n = 2).
2. Both right and left coronary ostia reimplanted using 2 short separate interposition grafts (n = 3).
3. Either right or left coronary ostium reimplanted using a separate interposition graft (n = 35).

The first modification is similar to the classic Cabrol technique, except that the interposition graft is anastomosed with coronary buttons cut out of the wall of the aorta and the remaining diseased aorta extirpated. In the original technique, the interposition graft is anastomosed with the coronary orifices using the inclusion technique. In this modification, the interposition graft was anastomosed side to side to the aortic graft. In modifications 2 and 3, the interposition graft was also anastomosed with coronary buttons, but was attached end to side to the neoaorta. In all cases, 8- to 10-mm tubular Dacron grafts were used according to the policy and practice of our institution to use the same size of the interposition graft, as was reported by Cabrol et al[5,7] in the original reports. In 27 cases (67.5%), the Dacron graft was anastomosed with the right coronary ostium; in 8 cases (20%) with the