

A STUDY OF SURGICAL OUTCOMES OF MODIFIED BENTALL'S PROCEDURE IN A TERTIARY CARE CENTRE IN SOUTH INDIA

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INTRODUCTION

The modified Bentall procedure remains a gold standard of aortic root surgery. ^[1] In 1968, Bentall and De Bono were the first to describe the surgical procedure for the reconstruction of the aortic root with a valved composite graft ^[2]. For years, this technique became the practice standard for surgical treatment of dysfunctions of the aortic valve, root, and ascending aorta ^[3-5]. In the original method, late intra-operative bleeding was controlled using circumferential suture lines on the coronary peri-ostium areas and an overall aortic wraparound ^[2]. In the initial series, the postoperative complications like coronary detachment, formation of a false aneurysm, and need for re-operation in the Bentall operation were very high ^[2]. Since then, with increased experience of the surgeon and technical improvements such as pre-clotting of grafts with albumin, enhancements in pump oxygenator systems, and accurate heparin adjustments the rate of complications has significantly dropped ^[6]. Several modified techniques have also been developed to further reduce the rate of complications and improve patient outcomes ^[4, 7, 8, 9]. Currently, the modified Bentall techniques that incorporate coronary button mobilization have become the procedure of choice in many centers around the world ^[10, 11, 12]. Despite significant improvements with modified techniques, intra-operative blood loss and postoperative complications remain a major cause of morbidity and mortality. Therefore, the present study aims to evaluate this technique of modified Bentall's procedure for various conditions of ascending Aorta and evaluate the outcomes in southern Indian population.

MATERIALS AND METHODS

The study was conducted in the Department of Cardiothoracic Surgery, Nizam's Institute of Medical Sciences, Hyderabad. This was a retrospective study which included patients who underwent Bentall's procedure for various reasons between December 2018 to December 2021. The patients who were undergoing concomitant procedure along with bentall's, patients with pre-existing renal and hepatic dysfunction and patients who underwent the procedure with hand sewn conduits were excluded from the study. A total of 33 patients underwent Bentall's procedure during

the 3 year period and of which 25 patients were found eligible for the study. The study was approved by the hospital Ethics and Research committee.

The data was collected from hospital records and recorded on predesigned proforma forms.

OPERATIVE TECHNIQUE

After induction of general anesthesia, a median sternotomy was performed. In cases where the aneurysm did not involve the distal portion of the ascending aorta or proximal portion of the aortic arch, these sites were used for arterial cannulation. In case, these sites were involved right axillary cannulation was preferred.

Venous cannulation was done using single two-stage cannula or bicaval cannulation strategy.

The patient was initiated on cardiopulmonary bypass after the desired ACT of 480 seconds was reached. The cooling of patient to 18 to 20° Celsius was initiated simultaneously.

The Aorta was then cross clamped and opened and ostial Delnido cardioplegia was given to arrest the heart. Cold saline was used topically to augment myocardial cooling.

The right and left coronary buttons were created before excision of valve leaflets.

Then the appropriate St Jude's Aortic valved conduit was placed in the Aortic annulus using 2-0 pledgeted polyester mattress sutures. The left and right coronary buttons were sewn to the graft using pericardial tissue washers. The distal anastomosis of the conduit to the proximal arch was done under deep hypothermic circulatory arrest. The dissection flap in the distal aorta was buttressed and closed with felt. During this time antegrade cerebral perfusion at 10ml/kg/min was given through the axillary artery by snaring the innominate artery. Following the procedure Aortic cross clamp was released and deairing was done through a cannula placed in the conduit.

The sternotomy was closed if patient had adequate hemostasis and hemodynamic stability, otherwise the chest was left open for delayed closure.

RESULTS

Total of 33 patients underwent Modified Bentall procedure from December 2018 to December 31st 2021. 25 patients fulfilled inclusion and exclusion criteria of our study. Out of the 25 patients, 17(68%) were male and 8(32%) were female.

Table-1: Demographic distribution

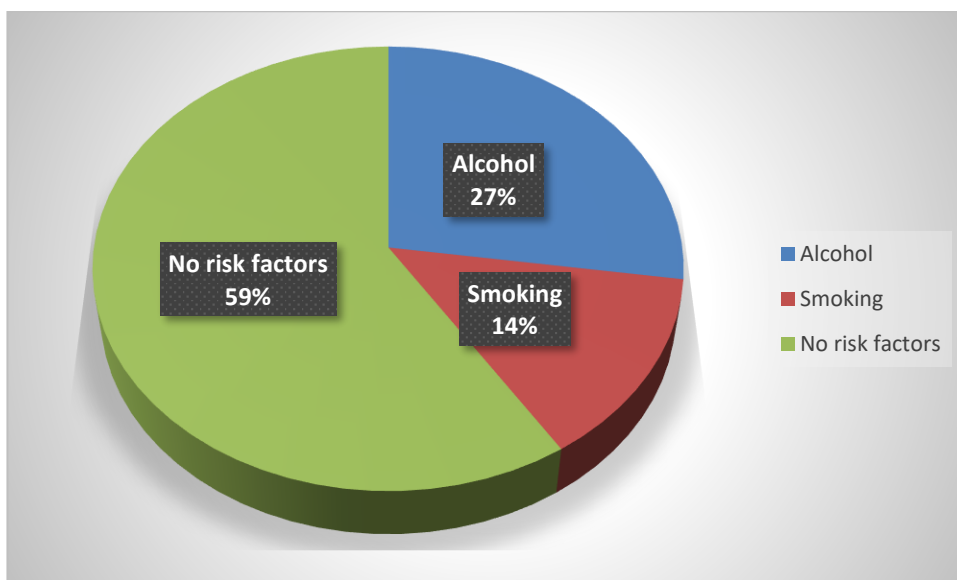
Age group(years)	Frequency	Percent
20-30	06	24%
30-40	04	16%
40-50	10	40%
50-60	03	12%
60-70	01	4%
70-80	01	4%
Gender		
Male	17	68%
Female	08	32%
Comorbidities		
HTN	15	60%
DM	02	08%

BOTH	02	08%
no comorbidities	06	24%

In the present study most of them are in 40-50 years age group of 10 (40%) members followed by 6 In 20-30 years group, 4 in 30-40 years, 3 in 50-60 years, 1 in 60-70 years, 1 patient in 70-80 years.

The most common comorbidity was Hypertension, present in 15(60%) ,patients,, Type 2 diabetes was present in 2 (08%) patients. Both hypertension and diabetes was present in 2(08%) patients.6(24%) patients had no comorbidities.

Figure-1: Risk factors associated in present study



Most common addiction was alcohol consumption seen in 6(24%) patients in the study followed by smoking seen in 3 (12%) patients. There were no addictions in 13 (52%) patients.

Table-2: Symptoms and there duration in present study

Symptoms	Total number	Percentage
Shortness of breath	06	24%
Chest pain	06	24%
Shortness of breath + chest pain	08	32%
Shortness of breath+chest pain + palpitations	02	8%
Shortness of breath +palpitations	01	4%
Shortness of breath + chest pain + vomiting	01	4%
Shortness of breath + chest pain+ loss of consciousness	01	4%
Duration of symptoms		
< 2 days	10	40%
2-4 days	10	40%
>4 days	05	20%

Most common symptom was shortness of breath and chest pain, seen in 8 (32%) patients and the next most common symptom was chest pain, seen in 6(24%) of patients followed by shortness of breath seen in 6 (24%).Shortness of breath and chest pain with associated palpitation was seen in 2(8%).there was associated vomiting in one(4%) patient

and loss of consciousness in one (4%) patient.

Most cases presented within 4 days of onset of symptoms, 5 patients presented late > 4 days after onset of symptoms.

Table-3: Etiology and diagnosis in present study

Etiology	Number of cases	Percentage
Unknown	06	24%
Connective tissue disorder	14	56%
Atherosclerosis	05	20%
Diagnosis		
Type-A aortic dissection	17	68%
Ascending aorta aneurysm	05	20%
Annulo aortic ectasia	03	12%

Most common aetiology was connective tissue disorder present in 14 cases, followed and unknown Aetiology in 6 patients and Atherosclerosis in 5 patients.

Most common lesion was type A aortic dissection seen in 17 (68%) patients followed by ascending aortic aneurysm in 5 (20%) patients. Annulo aortic ectasia was seen in 3 (12%) patients. Out of 25 cases, 15 (60%) cases were operated as emergency and the remaining 10 (40%) cases were operated electively.

Table-4: Surgical techniques performed in present study

Type of Surgery	Number of cases	Percentage
Emergency	15	60%
Elective	10	40%
Cannulation Techniques		
Aorta/Right Atrial	12	48%
Axillary	11	44%
Artery/Right Atrial		
Aorta/SVC, IVC	02	08%
Sternal closure		
Primary	04	16%
Delayed	21	84%

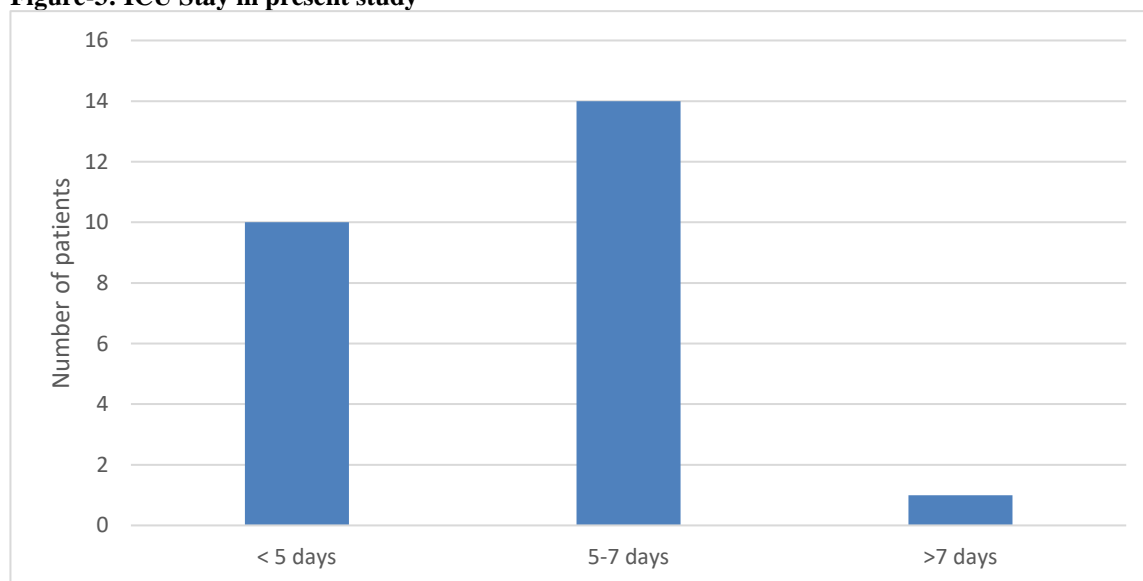
In this study, Aorta /Right Atrial Cannulation done in 12 (48%) patients, Axillary artery and Right Atrial cannulation was done in 11 (44%) patients, Aorto Bicaaval cannulation was done in 2 (8%) patients. In 21 (84%) cases delayed sternal closure was done on the next day and in the remaining 4 (16%) cases sternum was closed primarily.

Table-5: Amount of drain and number of transfusions in present study

Amount of drain	No of cases	Percentage
<100 ml	0	0%
100-300 ml	02	8%
300-500 ml	03	12%
500-700 ml	08	32%
700-900 ml	05	20%
900-1000 ml	03	12%
>1000 ml	04	16%
Number of transfusions		
<2	5	20%
2 – 4	18	72%
4 – 6	02	8%
>6	0	0%

In 8 (32%) patients postoperative bleeding was 500- 700 ml, In 5 (20%)of patients it was 700-900 ml. In 3 (12%) patients there was 300-500 ml of postoperative bleeding and in another 3(12%) cases 900-1000 ml bleeding was seen in the post-operative period. In 4 (16%) cases more than 1000ml bleeding was seen. Most patients (18) patients needed between 2- 4 units of blood transfusion. Only 2 (8%) patients needed more than 4 units of transfusion and 5 (20%) needed 2 or less than 2 transfusions.

Figure-3: ICU Stay in present study



Most of the patients in study are of more than 5 days and less than 7 days.

Table-6: Inotropic support present in present study

Inotropes	Number of Patients	Percentage
Minimal Support	02	8%
Moderate Support	19	76%
High Support	04	16%

In this study, of the 25 patients, 19 (76%) needed moderate inotropic support, 4 (16%) needed high inotropic support and 2 (8%) required low inotropic support.

Table-7: Post-operative outcomes and mortality

Dysfunction	Number of Patients	Percentage
Renal Dysfunction	04	16%
Hepatic Dysfunction	03	12%
Neurological Dysfunction	02	8%
Infection/Sepsis	00	0%
Death	5	20%
Survivors	20	80%

In the Postoperative period 4 (16%) patients developed renal dysfunction, 3 (12%) patients developed hepatic dysfunction and 2 (8%) patients developed neurological dysfunction. None of the patients developed infection or sepsis, which is remarkable considering the fact that 84% of patients had delayed sternal closure.

In this study of 25 patients, 5 patients died (20%), 20 (80%) patients survived.

DISCUSSION

Aortic root replacement with the reattachment of the 2 main coronary arteries was originally described by Bentall De Bono^[1]. This operation has undergone many modifications in the last 3 decades^[2]. Notable adaptations have been the creation of coronary buttons and their mobilization for to Aorta. Although the operation was originally designed to treat patients with Aortic root aneurysms the indications for radical root replacement have expanded to a variety of other conditions including aortic dissections and infective endocarditis with aortic root abscess.^[3,4,5]

Over the last few decades, there has been a considerable improvement in mortality rates in patients undergoing Modified Bentall procedure. The early and late mortality range between 0.7% to 12% in most studies^[8,9,10]. The disproportionate percentages in early mortality among several reports could be explained by different patient populations, concomitant procedures, and modifications in operative techniques or postoperative management strategies.

Since there are no national registries to study the outcomes of Bentall in different institutions in India, the individual institutional results remain the benchmark for comparing results of Modified Bentall. Our institute has a well-organized team comprising Cardiothoracic and Vascular Surgeons, Interventional radiologists, and Cardiologists. This study aims at assessing the outcomes of the procedure done since 2018 in our institute. Various studies have been done with valved conduits with St Jude Medical mechanical valve, assessing short- and long-term adverse effect. The results were excellent results in terms of survival and hemodynamic profile when used for various valve replacement procedures^[13,14].

There are limited and inconsistent reports in current literature regarding risk factors and surgical outcomes following modified Bentall's, particularly in the Indian scenario. Hence, we undertook this study to find possible answers for the inconsistencies with regard to risk factors, surgical techniques and their association to surgical outcomes following modified Bentall's procedure for various etiologies.

The following discussion is based mainly on the risk factors, surgical techniques, and their association with surgical outcome i.e., either mortality or morbidity. We understood and assimilated certain surgical techniques which helped us in improving outcomes such as Minimal dissection to harvest the Coronary buttons, Slight undersizing of the valve to put valve conduit, No mismatch between the pledgets at the aortic annulus. Use of pericardial "washer" for reinforcing the coronary buttons, which helps to absorb the pressure on the coronary buttons thus preventing cutting through of tissues. Immediately after surgery when we come off bypass, the suture lines are packed externally with pro-coagulating agents and gauze. Maintaining permissible hypotension, whilst keeping the sternum open overnight. The above principles allowed for early extubation, mobilization, and discharge of the patient. For cerebral protection, antegrade cerebral circulation was instituted via the right Axillary artery by clamping the Brachiocephalic artery during deep hypothermic circulatory arrest. Other procedures like the Elephant

trunk procedure were not needed as the tear in the aorta was limited to the distal ascending aorta and the arch vessels were arising from the true lumen in all our cases.

In our study, the mean age at presentation was 45 years and the mortality rate was 20% (5/25). Although the mortality was high in our study, no significant association was noted between age and mortality ($p=0.060$). Similar findings were noted in a study done by Meyer Judith et al in which no significant association was noted between age and mortality following modified Bentall's with p value of 0.621. Similar findings were noted in a study done by Aart Mookhoek et al in which no significant association was noted between age and morbidity following modified Bentall's with p value of 0.09^[15].

Of the 25 cases, 17 cases (68%) were male and 8 (32%) were female. In the 5 case where mortality 4 were males (16%) and 1 was female (04%). No significant association was found between gender and mortality (p value 0.5929). Similar findings were noted in a study done by Anton Sabashnikov et al, in which it was concluded that when considering patients with similar risk profiles, female gender per se was not associated with worse long-term survival and freedom from a stroke after surgery on Aorta (p value of 1.000)^[15].

Similar findings were noted in a study done by Meyer Judith et al., in which no significant association was noted between gender and mortality after modified Bentall's with p value of 0.09^[16]. In a study done by Philippe Pibarot et al., it was concluded that adjustment for other confounders revealed that the female gender is not an independent risk factor for mortality and that future studies should be focused on the identification of the preoperative and operative factors that are responsible for the increased operative mortality in this population.^[18]

Of 25 cases in the current study, morbidity was noted in 9 cases (36%) of which 6 were males and 3 were females. There is no significant association between gender and morbidity (p value 0.778). Similar findings were noted in a study done by Anton Sabashnikov et al in which it was noted that female patients might even benefit from a smoother early postoperative course and lower incidence of early postoperative complications and no significant association between gender and morbidity following modified Bentall's operation.^[15]

In our study of 25 cases, mortality was seen in 05 (20%) cases, out of which 02 (08%) cases had Hypertension, 1 case (04%) had Diabetes, and 1 case (04%) had both Hypertension and Diabetes. 1 case (04%) had no comorbidities. No significant association was noted between comorbidities and mortality with a p value of 0.677. Similar findings were noted in a study done by Meyer Judith in which no significant association was noted between comorbidities and mortality^[16].

4 patient (16%) had comorbidities in our series of which 02 (08%) had Hypertension, 1 had (04%) had Diabetes, 1 (04%) patient had both. No significant association was noted between comorbidities and morbidity (p value 0.400). Of the 05 cases in which mortality was noted, 2 patients (08%) were alcoholics, 1 (04%) patient was smokers and 1 patient (04%) had both risk factors, and no risk factors in 01 case (04%). No significant association was noted between risk factors and morbidity. Similarly no significant association was found between addictions and morbidity.

Of 5 patients who died, no patient had shortness of breath alone, whereas 1 (04%) patient had chest pain, 3 (12%) patients had both chest pain and shortness of breath, no patient had any combinations of chest pain, shortness of breath and palpitations. None of the patients had combinations of shortness of breath, chest pain and loss of consciousness. No significant association was noted between symptoms and mortality (p value 0.606). Similar findings were noted in a study done by Kenton et al in which no significant association was noted between symptoms and mortality, as seen in patients presenting with chest pain and palpitations^[17]. In our study we observed that in patients with type A aortic dissections the most common complaints were chest pain and shortness of breath.

Of 9 patients who had postoperative morbidity, 1 patient (04%) had shortness of breath and no patient had chest pain alone. Chest pain and shortness of breath was present in 2 (08%) patients. None of the patients had a combination of chest pain shortness of breath, no case had chest pain + shortness of breath and palpitations, no case had shortness of breath and palpitations, 1 (4%) patient had shortness of breath associated with chest pain and vomiting. No patient presented with shortness of breath associated with chest pain and loss of consciousness. No significant association was noted between symptoms and morbidity with (p value 0.659). Similar findings were not noted in other studies. In our study, 4 patients of type A Aortic dissection developed either renal, transient hepatic dysfunction or transient ischemic attacks.

We found that the duration of symptoms had an association with mortality and morbidity. In our study, we found that, of the total 25 patients who underwent modified Bentall's procedure, 10 patients presented within 2 days of onset of symptoms, 10 patients presented within 2-4 days of onset of symptoms, whereas 5 patients presented later than 4 days of onset of symptoms. All the 5 patients who died, had presented more than 4 days after symptoms onset. This association was found to be statistically significant with a p value of 0.0024. In these patients, who presented late to the hospital after symptom onset have had multiorgan dysfunction set in by the time he was wheeled into the theater. With regards to association between morbidity and duration of symptoms, no statistically

significance was found. We found that patients who presented after 4 days of onset of symptoms had high chances of morbidity and mortality.

In the 5 patients who died, all the patients had atherosclerosis as the underlying cause of dissections. Although our sample size was small we found a statistically significant association between mortality and etiology (p value 0.00738). We could not find any studies that had done similar analysis. Surprisingly, we could not find statistically significant association between morbidity and etiology (p value .1105). No significant association was noted between postoperative bleeding and morbidity (p value 0.851) and mortality (p value 0.235). No statistically significant association was found between mortality/morbidity and inotropic support and also with number of blood transfusion.

Of 25 cases in the current study, 10 cases (40%) underwent surgery on an emergency basis and 15 patients (60%) were operated electively. Mortality was seen in 5 patients (20%), all of whom underwent emergency modified Bentall's procedure. A significant association was noted between the emergency nature of surgery and mortality (p value of 0.0143). Similar findings were noted in a study done by Emily Pan et al^[19]. In their study the Kaplan–Meier analysis with log-rank test showed a significant difference in 30-day mortality (p<0.001) between patients treated emergently for dissection/rupture and electively for mainly aneurysms.

The morbidity noted in our study was seen in 9(36%) patients and all 9 of them had emergency surgery. A significant association was noted between the type of surgery(emergency) and morbidity with p= 0.0025. In our study, 15 cases were operated on in an emergency out of which 4 cases had mortality and 4 cases had morbidity. These cases presented late, i.e., there was 4 days interval between onset of symptoms and presentation to the hospital, and by that time, the disease progressed and multi-organ dysfunction had set in.

Mortality was noted in 5 (20%) of 25 cases in this study. The commonest cause of death was low cardiac output seen in 3 cases, followed by acute renal failure in 2 patients who needed dialysis. In a study by Kenton et al., mortality was 11.7% among those undergoing emergent procedures^[17]:

Judith et al in her study found the cause of death as low cardiac output syndrome in 3 patients, cerebrovascular complications in 4 patients, and respiratory or multiorgan failure in one patient each^[16]. Similarly Alessandro Della Corte et al found statistically significant association between mortality low-cardiac-output syndrome and pulmonary complications^[20].

In our study, mortality was noted in 5 cases, all of which, presented late after the onset of symptoms with a diagnosis of type A aortic dissection and were taken up for emergency surgery. At the time of presentation, all the cases had organ dysfunction with a rise in renal and transient hepatic enzymes with a history of TIA, which led to poor outcomes.

Postoperative complications were noted in 9 cases (36%) patients in the current study. Of these, 4(16%) patients had renal dysfunction, 3(12%) patients had hepatic dysfunction and neurological dysfunction was seen in 2(8%) patients. No patient developed infection/sepsis. Similar findings were noted in a study done by Kenton et al. In their study, they observed 3 cerebral strokes (1%), 10(5%) perioperative myocardial infarctions, and 8(4%) reoperations for bleeding^[17]. Judith et al had found similar reexploration and stroke rates^[16].

CONCLUSIONS

The longer duration between symptom onset and surgery was associated with high mortality. Similarly, atherosclerotic etiology of the aortic afflictions and emergency nature of surgery were associated with high mortality. Although patients with high inotropic support and multiple transfusions were expected to have high mortality, statistically significant association was not found. The use of deep hypothermic circulatory arrest along with selective antegrade cerebral circulation resulted in improved outcomes, although we did not include this aspect in our study. Further the use of improved local hemostatic agents also instrumental in improving early outcomes. The major limitation of the study were the limited numbers and also the retrospective nature of the study. Further the study did not include patients who underwent concomitant procedures.

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