

# 人工血管外翻改良Bentall手术治疗主动脉根部瘤的短期疗效

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## 摘要

目的: 探讨人工血管外翻改良Bentall手术在治疗主动脉瓣病变伴升主动脉瘤样扩张患者中的临床应用价值及手术效果。方法: 回顾性分析2020年1月~2024年1月在青岛大学附属医院西海岸院区心血管外科接受Bentall手术治疗的44例患者的临床资料。其中23例行人工血管外翻改良Bentall手术, 21例行纽扣法Bentall手术。统计分析患者的术前临床资料、术中、术后指标及随访结果。结果: 两组手术均未发生术中死亡。人工血管外翻改良Bentall手术组的体外循环时间、术后24小时引流量、术后拔除引流管时间、术后住院时间、术中输注血小板、凝血因子费用均少于纽扣法Bentall手术, 差异具有统计学意义( $P < 0.05$ )。两组患者术后复查左室内径、射血分数比较, 差异无统计性意义(均 $P > 0.05$ )。结论: 人工血管外翻改良Bentall手术, 能有效减少术中近端吻合口出血、渗血, 是一种安全有效的手术方式。

## 关键词

Bentall手术, 主动脉瓣置换, 主动脉根部置换, 手术改良, 临床分析

# Short-Term Efficacy of Modified Bentall Procedure with Outward Expansion of Artificial Graft for Aortic Root Aneurysm

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## Abstract

**Objective:** To explore the clinical application and surgical outcomes of the modified Bentall procedure with an outward expansion of the artificial graft in the treatment of patients with aortic valve disease complicated by ascending aortic aneurysm-like dilation. **Methods:** A retrospective analysis was conducted on the clinical data of 44 patients who underwent Bentall surgery between January 2020 and January 2024 at the cardiovascular surgery department of The Affiliated Hospital of Qingdao University, West Coast Branch. Among them, 23 patients underwent the modified Bentall procedure with an outward expansion of the artificial graft, and 21 patients underwent the button-type Bentall procedure. Preoperative clinical data, intraoperative parameters, postoperative outcomes, and follow-up results were statistically analyzed. **Results:** No intraoperative deaths occurred in either group. The modified Bentall procedure group had significantly shorter cardiopulmonary bypass time, lower postoperative 24-hour drainage volume, earlier removal of drainage tubes, shorter postoperative hospital stay, and lower costs for platelet and coagulation factor transfusion compared to the button-type Bentall procedure group ( $P < 0.05$ ). No statistically significant differences were found between the two groups in postoperative left ventricular diameter and ejection fraction (both  $P > 0.05$ ). **Conclusion:** The modified Bentall procedure with an outward expansion of the artificial graft can effectively reduce proximal anastomotic bleeding and oozing, making it a safe and effective surgical approach.

## Keywords

Bentall Procedure, Aortic Valve Replacement, Aortic Root Replacement, Surgical Modification, Clinical Analysis

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## 1. 引言

主动脉窦瘤是指主动脉根部瓦氏窦发生局限性扩张后导致主动脉窦直径  $> 5\text{ cm}$ ，是一种相对少见但潜在致命的心血管疾病。主动脉窦瘤的独立发病率相对较低，但在特定高风险人群中(如马凡综合征、Loeys-Dietz 综合征、Ehlers-Danlos 综合征、以及高血压患者)发病率显著增高[1]。马凡综合征患者中，主动脉根部扩张及主动脉窦瘤的发病率高达 50% [2]。主动脉窦瘤可引起多种并发症，包括破入心腔形成瘘管、压迫冠状动脉导致心肌缺血、主动脉瓣关闭不全、心包压塞等。由于本病进展隐匿，早期常无明显症状，确诊时多已出现并发症，因此具有较高的致死率。目前，对于单纯主动脉窦瘤，可采用 David 手术、Yacoub 手术、主动脉窦置换等保留主动脉瓣的手术方式；而对于合并主动脉瓣病变的患者，Bentall 手术是目前公认的标准术式[3]-[6]。经导管主动脉瓣置换术(TAVR)和杂交手术的发展，为高龄或高危患者提供了新的治疗选择。然而，开放手术仍是年轻、低危患者的首选治疗方案。多项研究表示术中渗血、止血困难是影响手术预后的重要因素[7] [8]。更有研究表明，术后出血是导致早期死亡的独立危险因素，术后出血致死率可达 15%~20% [9]。因此，本研究探讨采用人工血管外翻技术改良 Bentall 手术治疗主动脉根部瘤的临床效果，评估其在减少手术出血，缩短手术时间，改善手术预后并降低患者术后并发症的临床疗效。

2. 资料与方法

2.1. 一般资料和分组

回顾性分析 2018 年 2 月至 2024 年 2 月青岛大学附属医院心外科收治的 44 例行 Bentall 手术患者的临床资料，其中 37 例为主动脉根部瘤合并主动脉瓣膜病变，7 例为 A 型主动脉夹层，破口均位于主动脉根部。排除标准：(1) 二次心脏手术；(2) 同期需要合并其他心脏手术；(3) 左心室射血分数  $\leq 20\%$ ；(4) 严重肝肾功能不全或慢性阻塞性肺疾病。所有患者术前均进行心脏彩色超声心动图、胸部 CT、大血管增强 CT 或磁共振成像(MRI)等检查明确诊断。根据手术方式不同，将 44 例患者分为两组，M-Bentall 组：23 例，人工血管外翻改良 Bentall 手术；Bentall 组：21 例，纽扣法 Bentall 手术；2021 年 11 月之前，患者行纽扣法 Bentall 手术，之后均行人工血管外翻改良 Bentall 手术。两组患者详细的临床资料汇总于表 1。

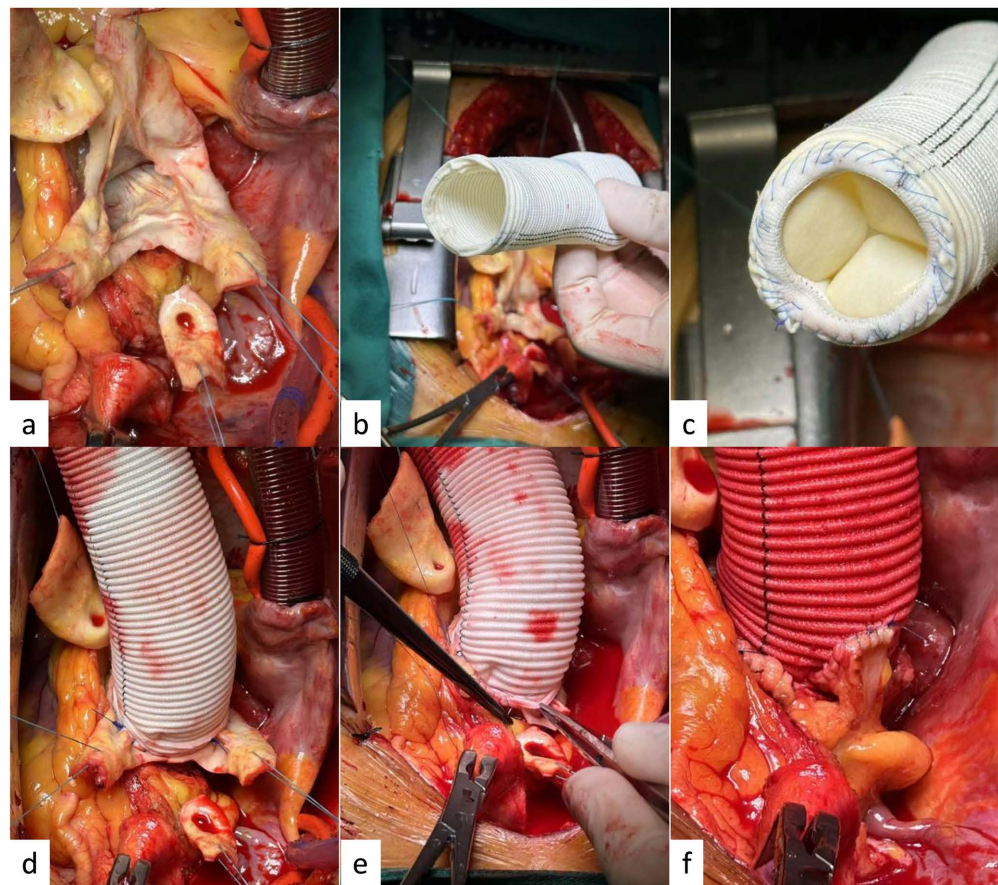
**Table 1.** Clinical data of patients in both groups  
**表 1.** 两组患者的临床资料

| Characteristic         | Patients, No. (%)  |                  | P Value |
|------------------------|--------------------|------------------|---------|
|                        | M-Bentall (n = 23) | Bentall (n = 21) |         |
| Age, mean (SD), y      | 26.0 (3.1)         | 24.0 (3.4)       | 0.358   |
| Sex                    |                    |                  |         |
| Female                 | 1 (4.3)            | 3 (14.3)         | 0.335   |
| Male                   | 22 (95.7)          | 18 (85.7)        |         |
| BMI, mean (SD)         |                    |                  | 0.051   |
| Smoke                  | 12 (52.2)          | 7 (33.3)         | 0.208   |
| Drink                  | 10 (43.5)          | 5 (23.8)         | 0.169   |
| History of surgery     | 4 (17.4)           | 6 (28.6)         | 0.481   |
| Hypertension           | 9 (39.1)           | 5 (23.8)         | 0.276   |
| Diagnosis              |                    |                  |         |
| 根部瘤                    | 22 (95.7)          | 15 (71.4)        | 0.042   |
| A 型夹层                  | 1 (4.3)            | 6 (28.6)         |         |
| Pre-surgery            |                    |                  |         |
| EF, median (IQR)       | 60 (54~62)         | 59 (51~61)       | 0.587   |
| 左室舒张末内径(mm), mean (SD) | 61.9 (8.7)         | 58.5 (10.9)      | 0.251   |

2.2. 手术方法

相同手术操作：所有手术均由同一团队完成，均正中开胸，股动脉或腋动脉或主动脉弓部动脉插管，右心房静脉插管建立体外循环，于右上肺静脉置入左心引流管。升主动脉阻断后，切开升主动脉，直视下灌注停跳液。心脏完全停跳后，剪除病变主动脉瓣。切除扩张的升主动脉，残端预留约 3 mm。“纽扣状”游离左右冠脉开口，测量左右冠脉开口与主动脉瓣环之间的距离，在人工血管上标记冠脉开口位置。(图 1(e)血液标记处即为右冠状动脉开口位置，左冠状动脉开口以相同方法标记)(图 1(a))。

改良 Bentall 组：人工血管根部翻折，重合约 5 mm (图 1(b))；应用 5-0 prolene 线连续缝合人工血管折叠部位与人工瓣膜(图 1(c))；以 5-0 prolene 线连续缝合主动脉瓣环与带瓣人工血管(图 1(d))；翻折人工血管根部，将之与预留主动脉壁连续缝合(图 1(e))；吻合左右冠状动脉开口(图 1(f))。



**Figure 1.** Treatment steps of aortic root in modified Bentall operation  
**图 1.** 改良 Bentall 手术主动脉根部处理步骤

传统 Bentall 组：以 5-0 prolene 线间断缝合 3 针，固定人工血管与人工瓣膜；以 5-0 prolene 线将带瓣人工血管缝合于主动脉瓣环。

**2.3. 观察指标和术后随访**

比较两组患者的手术时间、体外循环时间、主动脉阻断时间、术后拔除引流管时间、ICU 停留时间等围术期指标以及术后转归情况。术后对患者进行随访，所有患者均在术后 1、3、6 月复查心脏超声检查，术后 6 月复查胸腹主动脉 CTA。评估患者术后恢复情况及是否发生远期并发症。

**2.4. 统计分析**

采用 SPSS 26.0 软件进行统计分析。计量资料以均数 ± 标准差( $\bar{x} \pm s$ )表示，计数资料以例数和百分比表示。符合正态分布的计量资料组间比较采用独立样本 t 检验。不符合正态分布的计量资料采用 Wilcoxon 符合秩检验。计数资料组间比较采用卡方检验或 Fisher 确切概率法。以  $P < 0.05$  为差异具有统计学意义。

**3. 结果**

**3.1. 手术指标**

44 例患者手术均获成功，无围术期死亡。主要手术指标汇总于表 2。

两组手术时间比较, 差异无统计学意义( $P > 0.05$ )。与传统 Bentall 组相比, 改良 Bentall 组体外循环时间、术后 24 小时引流量、术后拔除引流管时间、术后住院时间、术中输注血小板、凝血因子费用明显减少, 差异具有统计学意义( $P < 0.05$ )。两组手术时间比较, 差异无统计学意义( $P > 0.05$ )。

**Table 2.** Comparison of surgical data between the two groups  
**表 2.** 两组患者的手术资料比较

| Variables          | Mean (SE) Score    |                    | MD/OR (95%CI)                | P Value |
|--------------------|--------------------|--------------------|------------------------------|---------|
|                    | M-Bentall (n = 23) | Bentall (n = 21)   |                              |         |
| 手术时长(min)          | 285.2 (57.5)       | 313.5 (45.8)       | -28.3 (-60.1, 3.5)           | 0.08    |
| 体外循环时间(min)        | 119.2 (23.5)       | 141.1 (34)         | -21.9 (-39.6, -4.3)          | 0.016   |
| 阻断时间(min)          | 85.4 (21.7)        | 98.4 (22.1)        | -13 (-26.4, 0.3)             | 0.055   |
| 术中红细胞 u, No. (%)   | 1 (4.3)            | 4 (19.1)           | 0.19 (0.02, 1.9)             | 0.176   |
| 术中输注血小板 No. (%)    |                    |                    |                              |         |
| 1 个治疗量             | 14 (60.9)          | 6 (28.6)           | 0.26 (0.07, 0.91)            | 0.04    |
| 2 个治疗量             | 9 (39.1)           | 15 (71.4)          |                              |         |
| 术中输注冷沉淀 u          | 10 (9.5~10)        | 10 (10~10)         | NA                           | 0.047   |
| 术中血浆 ml            | 420 (375~600)      | 590 (400~600)      | NA                           | 0.132   |
| 术后 24 小时引流量(ml)    | 175 (165~217.5)    | 245 (210~350)      | NA                           | 0.001   |
| 呼吸机时间(min)         | 14.5 (3.15)        | 15.5 (4)           | -1 (-3.2, 1.2)               | 0.358   |
| 监护室时间(h)           | 68 (63.5~81.5)     | 78 (67~105)        | NA                           | 0.129   |
| 术后带管时间(d)          | 8 (2.7)            | 12.2 (3.45)        | -4.2 (-6.1, -2.3)            | <0.001  |
| 术后出院时间(d)          | 10.9 (2.3)         | 14.7 (3.7)         | -3.8 (-5.7, -1.9)            | <0.001  |
| 住院总费用              | 156940.7 (22848.9) | 163053.2 (23370.6) | -6112.54244 (-20182.1, 7957) | 0.386   |
| 凝血因子费用, No. (Mean) |                    |                    |                              |         |
| No. (%)            | 10 (43.5)          | 16 (76.2)          | 0.24 (0.07, 0.88)            | 0.036   |
| 费用                 | 360 (360~360)      | 684 (540~4805)     | NA                           | 0.007   |

**3.2. 术后随访情况**

术后成功随访 37 例(84.1%)随访时间 6 个月。随访期间两组均未发现瓣周漏、冠状动脉吻合口漏等并发症。两组患者术后左室内径、射血分数比较, 差异无统计学意义。6 月数据缺失值使用 LOCF (last observation carried forward)法补齐。具体结果汇总于表 3。

**Table 3.** The postoperative data of the two groups were compared  
**表 3.** 两组患者术后相关数据比较

| Variables       | Mean (SE) Score    |                  | P Value |
|-----------------|--------------------|------------------|---------|
|                 | M-Bentall (n = 20) | Bentall (n = 17) |         |
| EF-3 month      | 58 (52.5~60)       | 59 (54~60)       | 0.31    |
| 左室舒张末内径-3 month | 49 (45~54.5)       | 49 (47~54)       | 0.776   |
| EF-6 month      | 60 (58~61.5)       | 60 (56~62)       | 0.241   |
| 左室舒张末内径-6 month | 48 (46~49.5)       | 46 (45~50)       | 0.623   |
| Mortality-6 m   |                    | 0                | 0       |
| 并发症发生率-6 m      |                    | 0                | 0       |

## 4. 讨论

Bentall 手术自 1968 年首次报道以来,已成为治疗主动脉瓣病变伴升主动脉瘤样扩张的标准术式[10]。然而,传统 Bentall 手术面临术中近端吻合口出血、渗血等技术难点,Bentall 及其同事将主动脉瘤壁包裹在近端吻合口,较高的术后早期吻合口出血[11]和假性动脉瘤的形成是经典 Bentall 手术主要的并发症[12]。研究报道假性动脉瘤的发病率为 7%~25% [13]-[15]。假性动脉瘤的形成往往导致二次手术[16]-[18]。1978 年,Cabrol 等对经典 Bentall 手术进行改良,采用主动脉瘤壁包裹技术和右房引流通道[19],但这可能会导致术后长期左向右分流,甚至出现充血性心力衰竭,如果引流通过早关闭,同时近端吻合口出血严重,会引起包裹部位缝线撕脱,导致二次开胸止血[20]。

1981 年,Kouchoukos 等提出了“裸”Bentall 手术概念,即主动脉根部不用任何组织包裹,这避免了包裹技术可能带来的并发症[21],但“裸”Bentall 近端吻合口无法避免地出现严重渗血,因此术中需要大量纤维胶体来止血[22],这会增加患者的住院花费,且术中止血时间会大大延长。后续出现多种改良 Bentall,如“蝴蝶袖”、“双袖技术”、“双环缝合”,或设计新型人工血管[23]-[26]但这些改良术式操作繁琐,并未被广泛应用。

本研究结果表明:我们采用人工血管外翻技术改良 Bentall 手术,提前将人工瓣膜缝合在人工血管上,从根本上杜绝了瓣周漏的发生。且只需将人工血管翻折部分与主动脉瓣环吻合,这样加快了缝合速度。所以,虽然看似手术步骤比传统纽扣法 Bentall 繁琐,但吻合时间较传统方法更短。虽然主动脉阻断时间暂无统计学意义,这可能是样本量较少导致。我们的新技术可明显减少术中近端吻合口渗血,进而减少用于止血的血小板量以及凝血因子费用。且术后吻合口渗出少,引流管拔出时间缩短,住院时间缩短。但本研究结果存在一定的局限性。本研究包含的样本量相对较小,随访时间较短。这些问题有待未来通过扩大样本量和延长随访时间来进一步验证。

综上所述,人工血管外翻改良 Bentall 术是可以有效减少术中主动脉根部渗血量及输血量,明显缩短拔除引流管时间及住院时间,是一种简单、有效又切实可行的新方法。但该技术广泛推广仍需进一步扩大样本量和长期随访。

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