ДРУЖЕСТВО НА КАРДИОЛОЗИТЕ В БЪЛГАРИЯ

Българска кардиология
том XXXII, 2026, № 2

АВТОРСКИ СТАТИИ
ORIGINAL ARTICLES

doi: 10.3897/bgcardio.32.e189464

MINIMALLY INVASIVE ASCENDING AORTIC SURGERY WITH PARTIAL UPPER STERNOTOMY: INSTITUTIONAL EXPERIENCE AND CONTEMPORARY PERSPECTIVE

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МИНИМАЛНО ИНВАЗИВНА ХИРУРГИЯ НА ВЪЗХОДЯЩАТА АОРТА С ЧАСТИЧНА ГОРНА СТЕРНОТОМИЯ: ИНСТИТУЦИОНАЛЕН ОПИТ И СЪВРЕМЕННА ПЕРСПЕКТИВА

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Abstract.

Background: Surgical replacement of the ascending aorta remains the gold standard therapy for ascending aortic aneurysm, chronic dissection, and selected aortic root pathologies. Traditionally performed through full median sternotomy, ascending aortic surgery has progressively evolved toward minimally invasive approaches aiming to reduce surgical trauma while preserving procedural safety and durability. Upper partial sternotomy has emerged as the most widely adopted minimally invasive access for ascending aortic surgery. This study presents the institutional experience of Acibadem City Clinic Vitosha Hospital with minimally invasive ascending aortic surgery via upper partial sternotomy and places these results in the context of contemporary literature. **Methods:** A retrospective analysis was conducted of consecutive elective patients undergoing ascending aortic replacement with or without aortic root intervention through an upper partial sternotomy. Demographic characteristics, operative details, and early postoperative outcomes were analyzed. Institutional results were interpreted considering current evidence comparing partial sternotomy with conventional full sternotomy, as well as alternative minimally invasive approaches including transaxillary and totally endoscopic techniques. **Results:** Minimally invasive ascending aortic surgery via upper partial sternotomy was associated with excellent early outcomes, including absence of early mortality, low neurological complication rates, limited blood transfusion requirements, and short intensive care and hospital stays. Cardiopulmonary bypass and aortic cross-clamp times were within acceptable ranges and comparable to those reported for conventional sternotomy in the literature. **Conclusions:** Upper partial sternotomy is a safe, reproducible, and effective minimally invasive approach for ascending aortic surgery in carefully selected patients. When performed in experienced centers, this technique provides outcomes comparable to full sternotomy while offering potential advantages in postoperative recovery. It represents a pragmatic and scalable strategy within the expanding field of minimally invasive aortic surgery.

Key words: minimally invasive cardiac surgery, partial upper sternotomy, ascending aorta, Bentall procedure, Wheat procedure

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Резюме.

Въведение: Хирургичното протезиране на възходящата аорта остава златен стандарт за лечение на аневризма на възходящата аорта, хронична дисекация и друга патология на аортния корен. Традиционно извършвана чрез пълна медианна стернотомия, тази хирургична интервенция постепенно еволюира към минимално инвазивни подходи с цел намаляване на хирургичната травма при запазване на безопасността и дълготрайността на резултатите. Частичната горна стернотомия се утвърди като най-широко възприетия минимално инвазивен достъп за хирургия на възходящата аорта. Настоящото проучване представя институционалния опит на болница Acibadem City Clinic Витоша с минимално инвазивна хирургия на възходящата аорта чрез частична горна стернотомия и поставя тези резултати в контекста на съвременната литература. **Методи:** Проведен е ретроспективен анализ на последователни пациенти за период от четири години от 2022 г. до 2025 г., подложени на протезиране на възходящата аорта със или без интервенция върху аортния корен през частична горна стернотомия. Анализирани са демографските характеристики, оперативните данни и ранните следоперативни резултати. Институционалните резултати са ин-

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терпретирани в светлината на наличните доказателства, сравняващи частичната стернотомия с конвенционалната пълна стернотомия, както и с алтернативни минимално инвазивни подходи, включително трансаксиларен и изцяло ендоскопски достъп. **Резултати:** Общо 50 пациенти са преминали през Отделението за период от 4 години. При 31 пациенти (62%) е извършена Wheat процедура (протезиране на асцендентната аорта и аортната клапа), а при 19 (38%) Bentall процедура, включваща протезиране на аортната клапа, корена на аортата и възходящата аорта. От изведените от нашия опит резултати установихме, че минимално инвазивната хирургия на възходящата аорта чрез парциална J-стернотомия е свързана с отлични ранни резултати, вкл. липса на ранна смъртност, без наличие неврологични усложнения постоперативно, намалена необходимост от използване на кръвни продукти и съкратен престой в интензивно отделение и болница. Времето на екстракорпорално кръвообращение и аортен клампаж бе в приемливи граници и съпоставимо с това при конвенционална стернотомия, докладвано в литературата. **Заключение:** Частичната горна стернотомия е безопасен, възпроизводим и ефективен минимално инвазивен подход за хирургия на възходящата аорта при внимателно подбрани пациенти. Прилагана в опитни центрове, тази техника осигурява резултати, сравними с пълната стернотомия, като същевременно предлага потенциални предимства по отношение на следоперативното възстановяване. Тя е адекватна стратегия в разширяващата се област на минимално инвазивната аортна хирургия. При извършване на процедурата от опитен кардиохирург, разполагащ с подходящ инструментариум, усложненията са редки.

Ключови думи: минимално инвазивна кардиохирургия, горна частична стернотомия, възходяща аорта, Bentall процедура, Wheat процедура

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Introduction

Diseases of the ascending aorta constitute a major indication for elective cardiac surgery and are associated with significant morbidity and mortality if left untreated. Ascending aortic aneurysm, bicuspid aortic valve-associated aortopathy, chronic aortic dissection, and aortic root dilatation represent the most frequent pathologies requiring surgical intervention [1-3]. Surgical replacement of the ascending aorta has demonstrated excellent long-term durability and remains the cornerstone of preventive treatment, effectively reducing the risk of rupture, acute dissection, and sudden death [1, 2].

For decades, full median sternotomy has been the standard surgical access for ascending aortic surgery, offering wide exposure of the heart and great vessels and allowing complex aortic reconstruction to be performed safely [3, 4]. However, full sternotomy is inherently invasive and associated with substantial surgical trauma, postoperative pain, prolonged recovery, and potential sternal complications such as infection, instability, and impaired respiratory mechanics [4]. These limitations have become increasingly relevant in an aging population with higher comorbidity burden.

The evolution of minimally invasive cardiac surgery has fundamentally changed the landscape of valve and coronary surgery and has progressively extended to proximal aortic procedures [5, 6]. Minimally invasive approaches aim to reduce access-related morbidity while maintaining the same oncologic – or in the case of aortic surgery, reconstructive – principles and long-term outcomes as conventional techniques. Among these approaches, upper partial sternotomy has gained widespread acceptance as a minimally invasive access for aortic valve and ascending aortic surgery [7, 8].

Upper partial sternotomy, usually performed as a J-shaped or inverted T incision to the third or fourth intercostal space, preserves the integrity of the lower sternum while maintaining a familiar midline surgical orientation [7]. This access allows central cannulation in most patients, facilitates safe myocardial protection, and enables performance of complex procedures such as composite aortic root replacement and valve-sparing root repair [8-10]. Importantly, several propensity-matched studies have demonstrated that ascending aortic and aortic root replacement via upper partial sternotomy yields perioperative mortality, neurological outcomes, and midterm survival comparable to full sternotomy [9-11].

In parallel with partial sternotomy, alternative sternal-sparing approaches have emerged. The transaxillary approach, developed in high-volume centers, allows minimally invasive aortic valve and selected ascending aortic procedures through a lateral incision with excellent cosmetic results [12, 13]. More recently, totally endoscopic right anterior mini-thoracotomy techniques have been applied to ascending aortic and even aortic root replacement, demonstrating the technical feasibility of completely avoiding sternotomy in carefully selected patients [14, 15].

Despite these advances, upper partial sternotomy remains the most broadly applicable minimally invasive approach for ascending aortic surgery, particularly during the establishment of a minimally invasive aortic program. The present study aims to report the expe-

rience of Acibadem City Clinic Vitosha Hospital with minimally invasive ascending aortic surgery via upper partial sternotomy, evaluate early outcomes, and discuss the role of this technique within the contemporary spectrum of minimally invasive aortic surgery.

Materials and Methods

Study Design and Patient Selection

This study is a retrospective observational analysis of consecutive adult patients undergoing elective ascending aortic surgery via upper partial sternotomy at Acibadem City Clinic Vitosha Hospital. All procedures were performed by a dedicated cardiac surgical team experienced in minimally invasive techniques.

Inclusion criteria consisted of patients undergoing isolated ascending aortic replacement or ascending aortic replacement combined with aortic root intervention. Indications for surgery followed current international guideline recommendations, including absolute aortic diameter thresholds, rapid aneurysm growth, presence of connective tissue disease, and associated aortic valve pathology [1, 2]. Patients with chronic type A dissection were included when surgical anatomy was favorable.

Exclusion criteria were acute type A aortic dissection, redo sternotomy, extensive aortic arch pathology requiring total arch replacement, porcelain aorta, and the need for concomitant coronary artery bypass grafting or complex multivalve surgery. These criteria were applied to ensure procedural safety during minimally invasive access.

Preoperative Evaluation

All patients underwent standardized preoperative assessment including transthoracic echocardiography, contrast-enhanced computed tomography of the thoracic aorta, and coronary angiography when clinically indicated. Attention was paid to the relationship between the ascending aorta and the sternum, extent of aortic pathology, and feasibility of central cannulation through a limited incision.

Table 1

Parameter	Value
Mean age (years)	56.7
Male sex, n (%)	36 (72%)
Female sex, n (%)	14 (28%)
Mean ejection fraction (%)	57.4
Arterial hypertension, n (%)	45 (98%)
Chronic kidney disease, n (%)	1 (2%)
Diabetes mellitus, n (%)	1 (2%)
Atrial fibrillation, n (%)	10 (19.6%)
Chronic obstructive pulmonary disease, n (%)	6 (10.8%)
History of ischemic stroke, n (%)	3 (6%)

Surgical Technique

All operations were performed under general anesthesia with continuous transesophageal echocardiographic monitoring. Patients were positioned supine. A midline skin incision was made from the sternal notch to the level of the third or fourth intercostal space. Upper partial sternotomy was performed in a J-shaped fashion extending into the right or left intercostal space. Fig 1, 2.

After pericardial opening, cardiopulmonary bypass was established using central aortic and right atrial cannulation in most patients. Peripheral cannulation was reserved for selected cases with unfavorable anatomy. Mild to moderate systemic hypothermia was employed depending on the extent of the procedure.

Myocardial protection was achieved using antegrade cold blood cardioplegia. The ascending aorta

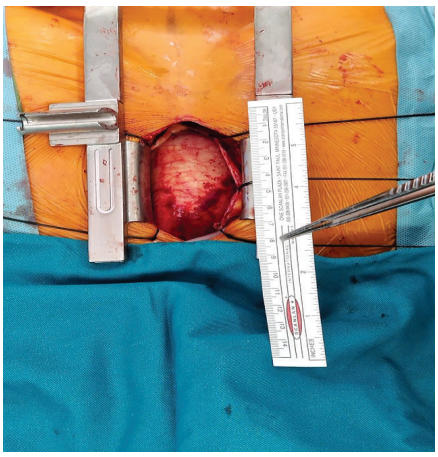

Fig. 1. Limited upper midline skin incision (approximately 6-7 cm) demonstrating reduced surgical access trauma

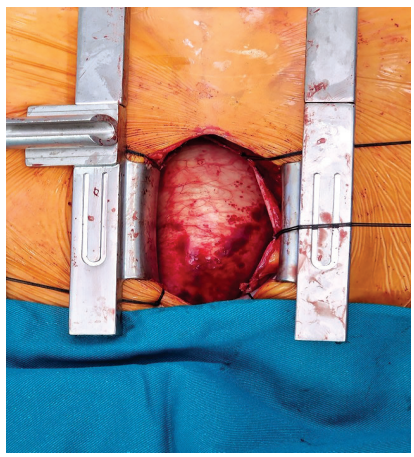

Fig. 2. Exposure of the ascending aorta through J-shaped upper partial sternotomy.

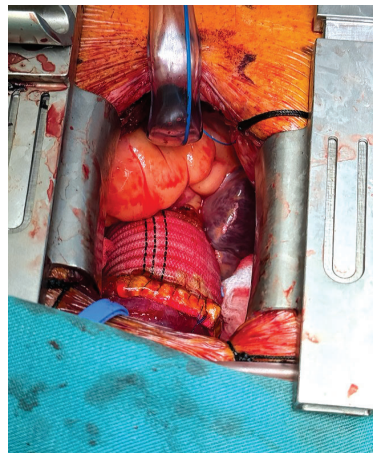

Fig. 3. Completed proximal anastomosis of the vascular graft with preserved operative field visibility through limited access

was replaced with a synthetic vascular graft using standard proximal and distal anastomotic techniques (Fig. 3). In patients requiring aortic root intervention, composite valve-graft implantation (Bentall procedure) or valve-sparing aortic root replacement was performed through the same access. Carbon dioxide insufflation and meticulous de-airing techniques under transesophageal echocardiographic guidance were routinely used.

At the conclusion of the procedure, the upper sternum was closed using standard wire fixation, preserving the integrity of the lower sternum.

Data Collection and Endpoints

Demographic data, operative variables, and postoperative outcomes were collected from institutional databases. Primary endpoints included early mortality, stroke, re-exploration for bleeding, renal failure, and wound complications. Secondary endpoints included cardiopulmonary bypass time, aortic cross-clamp time, transfusion requirements, intensive care unit stay, and total hospital length of stay.

Results

Patient Characteristics

Patients undergoing minimally invasive ascending aortic surgery via upper partial sternotomy represented a typical elective aortic surgery population. The majority were male, with a high prevalence of arterial hypertension and degenerative aortic disease. Bicuspid aortic valve morphology and associated aortopathy were frequently observed, consistent with established epidemiological data [16].

Operative Findings

All procedures were successfully completed through the planned upper partial sternotomy without conversion to full sternotomy. Central cannulation was feasible in most patients, confirming the practicality of this approach. Cardiopulmonary bypass and aortic cross-clamp times were within ranges reported for both minimally invasive and conventional sternotomy ascending aortic surgery [9-11].

Ascending aortic replacement was the most common procedure. In selected cases, aortic root replacement or valve-sparing root repair was performed without technical compromise. The surgical field provided by upper partial sternotomy allowed precise anastomotic work and safe coronary reimplantation when required.

Table 2

Parameter	Wheat (n = 31)	Bentall (n = 19)	Total (n = 50)
CPB time (min)	116 ± 18	149 ± 22	129 ± 25
Aortic cross-clamp time (min)	90 ± 14	122 ± 19	104 ± 22
Mechanical prosthesis, n (%)	2 (6.5%)	3 (15.8%)	5 (10%)
Biological prosthesis, n (%)	27 (87%)	14 (73.7%)	41 (82%)
Valve reconstruction, n (%)	2 (6.5%)	2 (10.5%)	4 (8%)
Reintubation, n (%)	0	0	0
Rehospitalization ≤30 days, n (%)	5 (16.1%)	3 (15.8%)	8 (16%)

Early Postoperative Outcomes

There was not early or in-hospital mortality. Neurological complications were rare and consistent with reported rates for ascending aortic surgery performed via full sternotomy [17]. Re-exploration for bleeding occurred infrequently and did not exceed rates reported in large series of conventional surgery [10].

No deep sternal wound infections or sternal instability were observed, reflecting the reduced sternal trauma associated with partial sternotomy. Blood transfusion requirements were limited, in line with evidence suggesting reduced bleeding with minimally invasive access [28].

Postoperative recovery was favorable, with short durations of mechanical ventilation and intensive care unit stay. Hospital length of stay was comparable or shorter than that reported for full sternotomy in the literature [29].

Table 3

Outcome	Value
30-day mortality, n (%)	0 (0%)
Neurological complications, n (%)	0 (0%)
Reoperation for bleeding, n (%)	0 (0%)
Pericardiocentesis (pericardial effusion), n (%)	7 (14%)
Pleural drainage, n (%)	4 (8%)
Permanent pacemaker implantation, n (%)	1 (2%)
Mean ICU stay (days)	2 ± 2
Mean hospital stay (days)	7 ± 3

Discussion

The present institutional experience demonstrates that minimally invasive ascending aortic surgery via upper partial sternotomy is safe, effective, and reproducible in carefully selected elective patients. These findings are consistent with a growing body of evidence supporting the use of partial sternotomy for proximal aortic surgery [7-11].

Several comparative studies have shown that partial sternotomy yields perioperative outcomes equivalent to full sternotomy with respect to mortality, stroke, and major complications [9, 10]. In a propensity score–matched analysis, Papadopoulos et al. reported no significant differences in early mortality or neurological events between partial and full sternotomy for ascending aortic and root surgery [9]. Similar findings have been reported by Angerer et al., who demonstrated comparable early and midterm outcomes between the two approaches [10].

One concern associated with minimally invasive aortic surgery is the potential for increased operative times. While some studies have reported modestly longer cardiopulmonary bypass and cross-clamp times during early adoption, this has not translated into worse clinical outcomes [10, 11]. Moreover, operative efficiency improves with experience, and institutional learning curves play a critical role in optimizing results.

Upper partial sternotomy offers several practical advantages. It preserves a familiar midline orientation, allows straightforward conversion to full sternotomy if necessary, and facilitates management of unexpected intraoperative findings. These characteristics make it particularly suitable as a foundational technique for centers developing a minimally invasive aortic surgery program.

Alternative minimally invasive approaches continue to evolve. The transaxillary approach has demonstrated excellent outcomes in large series of minimally invasive aortic valve surgery and selected ascending aortic procedures, with low mortality and favorable cosmetic results [12, 13] (Fig. 4) . Totally endoscopic right anterior mini-thoracotomy techniques have further expanded the boundaries of minimally invasive aortic surgery, allowing ascending aortic and root replacement without sternotomy in highly specialized centers [14, 15].

Fig. 4. Early postoperative aspect of the upper median sternotomy incision

Despite these advances, upper partial sternotomy remains the most widely applicable minimally invasive access for ascending aortic surgery. Its balance between reduced invasiveness and technical familiarity facilitates broader adoption and maintains a high level of procedural safety.

Patient selection remains essential. Elective patients without extensive arch involvement or complex concomitant procedures are best suited for this approach. When applied judiciously, upper partial sternotomy can serve as an integral component of a modern, patient-centered aortic surgery program.

Conclusions

Minimally invasive ascending aortic surgery via upper partial sternotomy is a safe and effective technique that achieves outcomes comparable to conventional full sternotomy. Institutional experience confirms low perioperative morbidity, absence of early mortality, and favorable postoperative recovery.

Upper partial sternotomy represents a pragmatic and scalable approach within the expanding spectrum of minimally invasive aortic surgery. Its adoption in experienced centers should be encouraged, with careful patient selection and adherence to established surgical principles.

No conflict of interest was declared

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