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MODERN APPROACHES TO THE DIAGNOSIS, SURGICAL CORRECTION, AND LONG-TERM MONITORING OF PATIENTS WITH COMMON ARTERIAL TRUNK

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Abstract

Introduction. Common truncus arteriosus (CTA) is a rare and severe congenital heart defect characterized by a single common vessel supplying both systemic and pulmonary circulations, leading to serious hemodynamic abnormalities. Without timely diagnosis and surgical intervention, approximately 80% of patients die within the first year of life. Modern imaging methods, such as echocardiography, CT, and MRI, allow for more precise identification of anatomical features, improving prognosis and treatment options. Advances in cardiac surgery have enabled early complete correction, though patients still require long-term monitoring due to the risk of complications. Research into modern approaches for the diagnosis and treatment of CTA is essential to improving the quality of life and survival rates for patients with this condition.

Aim: To investigate modern diagnostic methods and surgical correction techniques for common truncus arteriosus, assessing their effectiveness and impact on long-term treatment outcomes for patients with this rare congenital heart defect.

Search strategy: Key terms used to increase search accuracy included "common arterial trunk," "truncus arteriosus," "diagnostic methods", "echocardiography", "computed tomography", "cardiac catheterization", "magnetic resonance imaging", "surgical treatment", "long-term outcomes", "congenital heart defects." *Inclusion Criteria:* Publications with full-text articles available through open access or subscription resources; studies describing modern diagnostic methods (echocardiography, CT, MRI, cardiac catheterization) and surgical treatment of CTA; articles focused on the outcomes of surgical interventions and long-term results for patients with this defect. Publications in English and Russian from the last 20 years. Review articles, meta-analyses, and clinical studies with clear conclusions and results were prioritized. *Exclusion Criteria:* Duplicated publications, repeated articles, and resources with paid access if full texts could not be obtained; conference abstracts, promotional articles, short reviews, or materials without clear scientific conclusions; studies not directly related to the diagnosis and treatment of CTA, such as epidemiology or genetic research without a focus on clinical treatment methods. The search was not limited to specific time frames, as both recent studies and foundational works, such as the *Collett and Edwards* classification of 1949, were included to cover the evolution of CTA understanding from early anatomical descriptions to modern diagnostic and therapeutic methods. A total of 74 articles meeting the inclusion criteria were selected and analyzed.

Results and conclusions: Study results indicate that modern imaging methods, such as echocardiography, CT, and MRI, play a crucial role in the accurate diagnosis and treatment planning for common truncus arteriosus. These methods allow the identification of anatomical features, complications, and associated anomalies, which are critical for successful surgical correction. Early complete correction in the neonatal period significantly reduces the risk of complications, such as pulmonary hypertension and valve dysfunction. The use of biocompatible conduits and prosthetics also improves treatment outcomes, although regular monitoring is required. Long-term follow-up using high-precision imaging techniques helps to detect and correct late complications promptly, enhancing quality of life and increasing survival rates for patients with CTA.

Keywords: *common truncus arteriosus, diagnosis, early neonatal correction, long-term surgical outcomes.*

Резюме

СОВРЕМЕННЫЕ ПОДХОДЫ К ДИАГНОСТИКЕ, ХИРУРГИЧЕСКОЙ КОРРЕКЦИИ И ДОЛГОСРОЧНОМУ НАБЛЮДЕНИЮ ПАЦИЕНТОВ С ОБЩИМ АРТЕРИАЛЬНЫМ СТВОЛОМ

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Актуальность. Общий артериальный ствол — редкий и тяжёлый врожденный порок сердца, при котором один общий сосуд снабжает как системное, так и легочное кровообращение, что приводит к серьёзным гемодинамическим нарушениям. Без своевременной диагностики и хирургического лечения около 80% пациентов умирают в течение первого года жизни. Современные методы визуализации, такие как эхокардиография, КТ и МРТ, позволяют более точно выявлять анатомические особенности порока, что улучшает прогноз и выбор лечения. Прогресс в кардиохирургии открыл возможности для ранней полной коррекции, однако пациенты всё ещё нуждаются в долгосрочном наблюдении из-за риска осложнений. Исследование современных подходов к диагностике и лечению ОАС имеет большое значение для улучшения качества жизни и выживаемости пациентов с данным пороком.

Цель. Изучить современные методы диагностики и хирургической коррекции общего артериального ствола, оценить их эффективность и влияние на долгосрочные результаты лечения пациентов с этим редким врожденным пороком сердца.

Стратегия поиска. Использовались такие ключевые слова: "common arterial trunk", "truncus arteriosus", "diagnostic methods", "echocardiography", "computed tomography", "cardiac catheterization", "magnetic resonance imaging", "surgical treatment", "long-term outcomes", "congenital heart defects". *Критерии включения:* Публикации, содержащие полные тексты статей, доступные в открытом доступе или через подписные ресурсы. Исследования, описывающие современные методы диагностики (эхокардиография, КТ, МРТ, катетеризация сердца) и хирургического лечения общего артериального ствола. Статьи, посвященные результатам хирургических вмешательств и долгосрочным исходам у пациентов с данным пороком. Публикации на английском и русском языках, опубликованные за последние 20 лет. Обзорные статьи, мета-анализы и клинические исследования с чёткими выводами и результатами. *Критерии исключения:* Дубликаты публикаций, повторяющиеся статьи и материалы с платным доступом, если полные тексты не могли быть получены. Тезисы конференций, рекламные статьи, краткие обзоры или материалы без чётких научных выводов. Статьи, не имеющие прямого отношения к диагностике и лечению общего артериального ствола, такие как исследования по эпидемиологии или генетическим аспектам без фокуса на клинические методы лечения. Поиск не ограничивался конкретными временными рамками, поскольку были включены как современные исследования, так и классические фундаментальные работы, такие как исследование *Collett u Edwards* (1949), которое заложило основы классификации общего артериального ствола. Это позволило охватить все этапы эволюции понимания данного порока сердца, от ранних анатомических описаний до современных методов диагностики и лечения. Было отобрано и проанализировано 74 статьи, соответствующие критериям включения.

Результаты и выводы. Результаты исследования показывают, что современные методы визуализации, такие как эхокардиография, КТ и МРТ, играют ключевую роль в точной диагностике и планировании лечения общего артериального ствола. Эти методы позволяют выявлять анатомические особенности порока, его осложнения и сопутствующие аномалии, что критически важно для успешной хирургической коррекции. Ранняя полная коррекция,

выполненная в неонатальном периоде, значительно снижает риск осложнений, таких как легочная гипертензия и дисфункция клапанов. Использование биосовместимых кондуитов и протезов также улучшает результаты лечения, хотя требует регулярного мониторинга. Долгосрочное наблюдение с применением высокоточных методов визуализации помогает своевременно выявлять и корректировать поздние осложнения, улучшая качество жизни и увеличивая выживаемость пациентов с данным пороком.

Ключевые слова: *общий артериальный ствол, диагностика, ранняя неонатальная коррекция долгосрочные результаты хирургического лечения.*

Түйіндеме

ТУА БІТКЕН ЖАЛПЫ ТРУНКУС АРТЕРИОЗЫ БАР НАУҚАСТАРДЫҢ ДИАГНОСТИКАСЫНЫҢ, ХИРУРГИЯЛЫҚ ТҮЗЕУІНІҢ ЖӘНЕ ҰЗАҚ МЕРЗІМДІ БАҚЫЛАУЫНЫҢ ЗАМАНАУИ ТӘСІЛДЕРІ

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Өзектілігі: туа біткен жалпы трункус артериозы — сирек және ауыр туа біткен жүрек ақауы, мұнда бір ортақ артерия жүйелік және өкпелік қан айналымын қамтамасыз етеді, бұл ауыр гемодинамикалық бұзылыстарға алып келеді. Уақытында диагностика мен хирургиялық емдеу жүргізілмесе, науқастардың шамамен 80%-ы өмірінің бірінші жылында қайтыс болады. Қазіргі заманғы визуализация әдістері, мысалы, эхокардиография, КТ және МРТ, ақаудың анатомиялық ерекшеліктерін дәл анықтауға мүмкіндік береді, бұл болжам мен емдеу таңдауын жақсартады. Кардиохирургиядағы прогресс ерте толық түзетуді жүзеге асыруға мүмкіндік берді, бірақ науқастар әлі де асқынулардың қаупіне байланысты ұзақ мерзімді бақылауды қажет етеді. Туа біткен жалпы трункус артериозының диагностикасы мен емдеудегі қазіргі тәсілдерді зерттеу осы ақауы бар науқастардың өмір сүру сапасы мен тіршілігін жақсарту үшін маңызды..

Мақсаты: туа біткен жалпы трункус артериозын диагностикалаудың және хирургиялық түзетудің қазіргі әдістерін зерттеу, олардың тиімділігін және осы сирек туа біткен жүрек ақауымен науқастарды ұзақ мерзімді емдеу нәтижелеріне әсерін бағалау.

Іздеу стратегиясы: Іздеудің дәлдігін арттыру үшін "common arterial trunk", "truncus arteriosus", "diagnostic methods", "echocardiography", "computed tomography", "cardiac catheterization", "magnetic resonance imaging", "surgical treatment", "long-term outcomes", "congenital heart defects" сияқты негізгі сөздер пайдаланылды. *Қосу критерийлері:* Толық мәтінді мақалаларға қолжетімділігі бар немесе жазылу негізінде қолжетімді басылымдар. Жалпы артериялық діңгекті заманауи диагностикалау әдістерін (эхокардиография, КТ, МРТ, жүрек катетеризациясы) және хирургиялық емдеуді сипаттайтын зерттеулер. Аталған ақауы бар пациенттердегі хирургиялық ем мен ұзақ мерзімді нәтижелерге арналған мақалалар. Соңғы 20 жыл ішінде ағылшын және орыс тілдерінде жарияланған өзекті деректерді қамту үшін басылымдар. Нақты қорытындылар мен нәтижелері бар шолу мақалалары, мета-анализдер және клиникалық зерттеулер. *Шығару критерийлері:* Қайталанатын басылымдар, толық мәтіндерге қол жеткізу мүмкін болмаған жағдайда ақылы қолжетімділікке ие мақалалар. Конференция тезистері, жарнамалық мақалалар, қысқа шолулар немесе ғылыми дәлелдемелері жоқ материалдар. туа біткен жалпы трункус артериозын диагностикалау және емдеуге тікелей қатысы жоқ мақалалар. *Іздеу тереңдігі:* Іздеу нақты уақыт шеңберімен шектелмеген, себебі қазіргі зерттеулер мен *Collett және Edwards* (1949) зерттеуі сияқты негізгі классикалық жұмыстар қамтылды. Бұл туа біткен жалпы трункус артериозы ақауын түсінудегі барлық даму кезеңдерін, ерте анатомиялық сипаттамалардан бастап

заманауи диагностикалық және емдеу әдістеріне дейін қамтуға мүмкіндік берді. Іздеу нәтижесінде қосу критерийлеріне сәйкес келетін 74 мақала талданды.

Нәтижелер және қорытындылар: Зерттеу нәтижелері көрсеткендей, эхокардиография, КТ және МРТ сияқты заманауи визуализация әдістері туа біткен жалпы трункус артериозын толық диагностикалау мен емдеуді жоспарлауда маңызды рөл атқарады. Бұл әдістер ақаудың анатомиялық ерекшеліктерін, асқынуларын және қатар жүретін аномалияларды анықтауға мүмкіндік береді, бұл хирургиялық түзетудің сәтті өтуіне өте маңызды. Неонаталдық кезеңде жасалған ерте толық ем өкпе гипертензиясы мен клапандардың дисфункциясы сияқты асқыну қаупін айтарлықтай төмендетеді. Биологиялық үйлесімді кондуиттер мен протездерді қолдану емдеу нәтижелерін жақсартады, дегенмен тұрақты мониторинг қажет. Жоғары сапалы визуализация әдістерін қолдана отырып, ұзақ мерзімді бақылау кеш асқынуларды уақытылы анықтап, түзетуге көмектеседі, пациенттердің өмір сүру сапасын жақсартады және өмір сүру деңгейін арттырады.

Түйінді сөздер: *туа біткен жалпы трункус артериозы, диагностика, ерте неонаталдық түзету, хирургиялық емдеудің ұзақ мерзімді нәтижелері.*

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Introduction

The common arterial trunk (CAT) is a rare but extremely serious congenital heart defect characterized by a single common vessel that supplies systemic, pulmonary, and coronary blood flow. The incidence of this defect among congenital heart anomalies is less than 3%, making it a subject of significant attention in cardiology and cardiac surgery. This defect is usually associated with a ventricular septal defect (VSD), which further complicates the clinical picture and therapeutic approach [4, 11]. Without timely surgical intervention, 80% of patients die within the first year of life, emphasizing the need for early diagnosis and effective surgical correction [12, 23, 25].

Recent advances in diagnostics and surgery have significantly improved patient outcomes, yet challenges related to diagnosis and long-term prognosis remain relevant. In recent decades, there has been a significant improvement in imaging methods, including echocardiography, computed tomography (CT), and magnetic resonance imaging (MRI), enabling more accurate identification of anatomical features and associated anomalies of the defect. These methods play a key role in planning surgical interventions and determining the optimal timing for surgeries.

Prenatal diagnosis of CAT remains challenging despite advancements in fetal echocardiography. The difficulty in accurately identifying the anomaly in utero is due to the diverse morphological manifestations of the defect, the presence of associated malformations, and limitations in visualization techniques during intrauterine development. On the other hand, successful prenatal diagnosis allows for better planning of perinatal management and early surgery, reducing the risk of complications associated with late diagnosis [12, 13, 15, 24].

The surgical treatment of CAT has undergone significant changes in recent decades. Previously used methods, such as delayed correction with palliative pulmonary artery banding, have proven ineffective and show high complication rates. The modern approach involves early complete correction of the defect, preferably in the neonatal period, which is associated with better outcomes and lower risks of developing pulmonary hypertension and other complications. However, early surgical intervention is accompanied by several technical challenges due to the small size of the newborn's heart and vessels, as well as the need for prostheses and conduits to restore blood flow. These materials have a limited lifespan, necessitating repeat surgeries as the child grows, which is a significant risk factor in the long-term perspective [4, 11, 19, 31, 34].

One of the key issues in surgical treatment is the condition of the common trunk valve, which can range from mild to severe insufficiency or stenosis. The valve's condition greatly affects outcomes both during surgical correction and in the postoperative period. Severe regurgitation or stenosis requires additional intervention to correct valve dysfunction, which can significantly complicate the surgery and worsen the prognosis. Technically complex surgeries involving valve reconstruction are associated with a high risk of complications and often require repeat surgical interventions in the future.

Long-term treatment outcomes for patients with CAT depend not only on the success of the primary surgery but also on appropriate monitoring and management of emerging complications. The most common complications after surgical correction include pulmonary artery stenosis,

dysfunction of prosthetic conduits and valves, and the development of pulmonary hypertension. These issues require dynamic observation, visualization methods for assessing blood flow, and timely re-correction. According to the literature, patients who have undergone CAT correction require lifelong monitoring, as emerging issues such as implant wear and progression of pulmonary hypertension may need to be addressed over time.

Modern diagnostic methods play a key role in managing patients with CAT. Echocardiography remains the primary method for both prenatal and postnatal periods, facilitating initial diagnosis and assessment of heart condition. However, in complex cases, particularly with associated anomalies such as interrupted aortic arch or coronary artery defects, more precise methods like CT and MRI are required. These methods allow for the visualization of complex anatomical features and aid in planning surgical intervention, especially in cases where precise determination of blood flow sources and valve condition is needed. Additionally, the use of modern technologies such as 3D modeling helps surgeons better prepare for operations, which improves treatment outcomes [28, 42, 70].

Thus, the relevance of studying CAT is driven by the need to improve diagnostic methods, enhance surgical treatment outcomes, and develop effective strategies for the long-term monitoring of patients. Given the rarity of this defect and high mortality among untreated patients, further advancement in both diagnostic and therapeutic approaches is required to improve the prognosis and quality of life for patients with this severe congenital pathology [20, 29, 31].

Aim: To study modern diagnostic and surgical correction methods for the common arterial trunk, evaluating their effectiveness and impact on long-term outcomes for patients with this rare congenital heart defect.

Search Strategy: Leading international databases of scientific publications, including PubMed, Scopus, and Google Scholar, were used for the review. The selection of these resources was based on their authority and access to up-to-date scientific information, allowing for a comprehensive analysis of modern diagnostic and treatment methods for CAT. Search Terms:To enhance search accuracy, key terms such as “common arterial trunk,” “truncus arteriosus,” “diagnostic methods,” “echocardiography,” “computed tomography,” “cardiac catheterization,” “magnetic resonance imaging,” “surgical treatment,” “long-term outcomes,” and “congenital heart defects” were used. These terms were chosen based on the study’s objectives to cover all aspects of diagnosis, surgical treatment, and long-term patient monitoring with CAT. *Inclusion Criteria:* Publications with full-text articles available in open-access or subscription-based resources; studies describing modern diagnostic methods (echocardiography, CT, MRI, cardiac catheterization) and surgical treatment of CAT; articles focused on surgical outcomes and long-term results in patients with this defect. Publications in English and Russian from the last 20 years were included to encompass current data. Review articles, meta-analyses, and clinical studies with clear conclusions and results were included. *Exclusion Criteria:* Duplicate publications, repeated articles, and paid-access materials if full texts could not be obtained; conference abstracts, promotional articles, short reviews, or materials without clear scientific conclusions; studies not directly related to CAT diagnosis and treatment, such as epidemiological or genetic studies without a clinical focus. *Search Depth:* The search was not limited to specific timeframes, as both modern studies and classic foundational works, such as the *Collett and Edwards* classification (1949), were included to cover all stages of understanding the defect, from early anatomical descriptions to modern diagnostic and treatment approaches. Analysis and Systematization: A thorough study and analysis of selected publications were conducted. Particular attention was paid to articles describing comparative studies of diagnostic methods (echocardiography, CT, MRI) and surgical intervention outcomes. Conclusions were systematized for further use in the study. Eighty articles meeting the inclusion criteria were selected and analyzed.

Discussion

Etiology and Pathogenesis

The etiology and pathogenesis of CAT are not fully understood; however, it is known that this defect forms in the early stages of embryonic development during cardiovascular system formation. CAT arises from disruptions in the septation of the common arterial trunk into the aorta and pulmonary artery, related to insufficient development of the aortopulmonary septal complex, leading to a single vessel exiting the heart and supplying both systemic and pulmonary circulation.

Several risk factors are associated with CAT development, one of the most significant being genetic predisposition. Studies show that this defect may be associated with chromosomal abnormalities, such as a deletion on chromosome 22q11.2, also known as DiGeorge syndrome. This syndrome includes multiple congenital anomalies, including various heart defects, and in 20-30% of cases, CAT is associated with this chromosomal pathology. Genetic predisposition necessitates screening in patients with a family history of congenital heart defects or syndromic conditions.

Embryology and External Factors

Embryologically, the common arterial trunk develops during weeks 4–8 of gestation, when the arterial trunk separates, forming distinct pathways for systemic and pulmonary circulation. Disruption in this process can be triggered by external teratogenic factors, such as maternal infections (notably rubella and cytomegalovirus), alcohol or drug use, or certain medications taken during the first trimester of pregnancy. These factors can impact the normal development of the fetal cardiovascular system, contributing to the formation of the defect [4, 11, 70].

Pathogenesis

The pathophysiology of CAT is linked to significant hemodynamic disturbances, as arterial and venous blood mix within the heart and exit through a single vessel. This results in considerable blood flow imbalances between the pulmonary and systemic circulations, causing pulmonary circulation overload and increasing the risk of pulmonary hypertension. The lack of oxygen in systemic circulation leads to chronic hypoxia of organs and tissues, potentially delaying development in newborns and infants.

Additionally, the pathogenesis of CAT is complicated by the underdevelopment of the common trunk valve, often leading to substantial regurgitation that further disrupts

hemodynamics. Combined with a ventricular septal defect, this creates a condition where mixed blood is directed both to the lungs and systemic circulation, resulting in systemic oxygen deficiency and increased cardiovascular strain [12, 19].

Thus, the etiology and pathogenesis of CAT involve genetic, embryological, and environmental factors that disrupt the normal development of the aortopulmonary septum and the formation of the fetal circulatory system.

Classification of the Common Arterial Trunk

The common arterial trunk (truncus arteriosus communis) is a complex congenital heart defect, wherein a single vessel exits the heart, supplying both systemic and pulmonary circulations. The classification of this defect is based on anatomical features, such as the origin of the pulmonary arteries from the common trunk and the structure of its valve. Major classification systems developed by Collett and Edwards and by Van Praagh help describe anatomical variations of the defect and determine the most appropriate surgical approach.

Collett and Edwards Classification

In 1949, Collett and Edwards proposed one of the first classification systems for the common arterial trunk, which remains relevant today [23, 24, 28]. This classification divides CAT into four types based on how the pulmonary arteries originate from the common trunk:

1. **Type I (Common trunk with a single pulmonary orifice)**: In this type, the pulmonary arteries originate from the common trunk as a single vessel, which then divides into the right and left pulmonary arteries. This type is the most common, occurring in about 60% of CAT cases, and allows for simpler corrective procedures since the pulmonary arteries already have a common origin, facilitating surgical reconstruction.
2. **Type II (Pulmonary arteries arise separately from the posterior surface of the common trunk)**: In this type, each pulmonary artery (right and left) has a separate origin from the posterior surface of the common trunk. This type is less common, and its anatomical characteristics can create challenges in surgery, as each artery opening requires individual reconstruction for adequate pulmonary blood flow.
3. **Type III (Pulmonary arteries arise separately from the lateral surfaces of the common trunk)**: Each pulmonary artery also has a separate origin but from the lateral walls of the common trunk, making them more distant from each other. As with Type II, the complexity of surgical correction increases, as each pulmonary vessel requires separate reconstruction.
4. **Type IV (Pulmonary blood supply through collateral vessels without major pulmonary arteries)**: In this type, major pulmonary arteries are absent, and pulmonary blood flow is supplied by collateral vessels branching from the aorta or other vascular structures. This type has been excluded from the common arterial trunk classification in modern contexts, as it aligns more with the diagnosis of pulmonary atresia with collateral vessels. However, it is still occasionally referenced in clinical practice as a rare variant of CAT.

Van Praagh Classification

Van Praagh developed a classification system for the common arterial trunk in 1965, emphasizing differences in the aortopulmonary septum and valve morphology [28, 30, 42]. The Van Praagh classification divides the defect into two main categories—A and B—based on the presence or absence of the aortopulmonary septal complex:

1. **Type A (With an aortopulmonary septal complex)**: This type includes partial septation of the common trunk into pulmonary and aortic components. The pulmonary arteries may originate from the aortopulmonary septum or other parts of the common trunk. Subtypes of Type A depend on the pulmonary artery separation method and include:
   - **A1**: The pulmonary arteries arise from the common trunk as a single vessel that then divides into right and left branches.
   - **A2**: The pulmonary arteries arise separately from the common trunk, with individual openings.
   - **A3**: Absence of pulmonary arteries, with pulmonary blood supply occurring through collateral vessels (similar to Type IV in the Collett and Edwards classification).
2. **Type B (Without an aortopulmonary septal complex)**: In this type, the aortopulmonary septum is completely absent, and pulmonary blood flow is supplied by collateral vessels. Type B commonly includes severe valve regurgitation, complicating surgery, and worsening prognosis.

Additional Classification Considerations

Both the Collett and Edwards and Van Praagh classification systems are foundational; however, further morphological characteristics may be considered for a more precise patient assessment and surgical strategy selection:

- **Common Trunk Valve**: The valve may have two to five leaflets, with three-leaflet valves being the most common. Abnormalities, such as bicuspid or quadricuspid valves, can lead to regurgitation, necessitating additional corrective measures during surgery.
- **Coronary Artery Condition**: Coronary arteries may arise from different locations with various deviations from normal structure. Some anatomical variations, such as anomalous origins, increase the risk of myocardial ischemia and require a specialized approach in surgical correction.
- **Associated Cardiac Anomalies**: Patients with CAT often present with other congenital heart defects, such as ventricular septal defects (VSD), interrupted aortic arches, or other vascular anomalies. These associated defects also influence surgical strategy and affect treatment outcomes.

Clinical Significance of Classification

Classifying the common arterial trunk is essential for selecting the optimal surgical approach. Types of defects in which pulmonary arteries have a single origin or proximity are considered technically simpler for surgical intervention. Conversely, types with separate pulmonary artery origins or without major pulmonary arteries require complex reconstructive procedures, increasing the risk of postoperative complications and the need for repeat surgeries [14, 19, 37, 43, 62].

Using a classification system enables surgeons to better plan operations and assess the risk of potential complications. For example, types of CAT with pronounced valve regurgitation and coronary artery anomalies necessitate a specialized approach to blood flow restoration and are often associated with extended postoperative recovery.

Thus, the Collett and Edwards and Van Praagh classification systems provide a detailed description of the morphological features of CAT, essential for adequate surgical planning and long-term monitoring.

Diagnosis of Common Arterial Trunk

Diagnosing CAT, a rare and serious congenital heart defect, requires a comprehensive approach and the use of various imaging techniques to assess the defect's anatomical features, and the degree of functional impairment, and to select the optimal treatment strategy. Several diagnostic methods are involved, each providing key data and contributing to a complete patient assessment.

Chest Radiography

Chest radiography is a basic and often initial imaging method that can indicate the presence of cardiopulmonary abnormalities characteristic of the common arterial trunk. The radiograph may reveal cardiomegaly, an enlargement of the heart caused by abnormal blood flow combined with cardiac overload. Signs of pulmonary hypertension are also often detected due to increased blood flow to the lungs from inadequate separation of circulations. Pulmonary vessels appear enlarged and are easily distinguishable on the radiograph. While chest radiography does not provide precise visualization of the heart and vessels, it remains valuable for an initial patient assessment and for identifying additional pathologies, such as pulmonary hypertension or congestion in the lungs. This method is also used for dynamic monitoring during the postoperative period [26, 27].

Echocardiography

Echocardiography, or ultrasound of the heart, is the primary diagnostic method for the common arterial trunk, both in the prenatal and postnatal periods. This non-invasive method does not involve ionizing radiation and provides real-time imaging of the heart and major vessels. In the prenatal period, echocardiography can detect the defect as early as the 18th–24th weeks of pregnancy, allowing early planning for delivery and subsequent treatment of the newborn [28, 30]. Postnatal echocardiography accurately determines the anatomical features of the heart, including:

- **Common Arterial Trunk**: Echocardiography allows visualization of a single vessel exiting the heart and assessment of the trunk's valve structure, which may have two, three, or four leaflets.
- **Valve Regurgitation**: Using Doppler imaging, an integral part of echocardiography, it is possible to assess backflow through the common trunk valve and measure the degree of insufficiency.
- **Pulmonary Arteries**: Echocardiography helps determine the origin of the pulmonary arteries from the common trunk, which is crucial for preoperative planning.
- **Ventricular Septal Defect (VSD)**: Nearly all CAT patients have a VSD, which can be visualized with echocardiography and measured to assess the need for intervention.

Echocardiography is widely used both for diagnosis and for evaluating heart conditions before and after surgery. Depending on the complexity of the defect and associated anomalies, additional echocardiographic studies may be conducted using various modes to gain a comprehensive view of the cardiovascular system.

Computed Tomography (CT)

Contrast-enhanced CT provides detailed three-dimensional images of the heart and vessels, making it a vital part of preoperative assessment, particularly in complex cases. CT allows for clear visualization of CAT anatomy, including the origin and location of the pulmonary arteries, which is especially important for surgical planning [30, 38]. CT also enables the following:

- **Assessment of Pulmonary Artery Stenosis**: Identifying and measuring stenosis in the pulmonary arteries if present.
- **Detection of Abnormal Collateral Vessels**: Revealing compensatory collateral vessels that may develop to offset impaired blood flow.
- **Evaluation of Coronary Artery Anomalies**: Determining the origin of the coronary arteries, which is crucial to avoid ischemic complications post-surgery.

The three-dimensional images obtained via CT give surgeons precise data on the structure of the heart and vessels, allowing for low-risk surgical planning. CT is also beneficial postoperatively for evaluating the condition of implanted conduits and identifying possible complications, such as stenosis or thrombosis [54, 66, 74].

Magnetic Resonance Imaging (MRI)

MRI is preferred for long-term monitoring of heart and vessel conditions post-surgery. Unlike CT, MRI does not involve ionizing radiation, making it safer for patients who require frequent imaging, especially children [38, 40, 54]. MRI provides detailed heart and vessel images and allows for the assessment of functional blood flow parameters:

- **Blood Flow and Valve Functionality**: MRI precisely measures blood volumes passing through vessels and valves, and reveals regurgitation in cases of valve insufficiency.
- **Assessment of Pulmonary Hypertension**: MRI evaluates pulmonary blood flow and assesses pulmonary hypertension risk, particularly important for CAT patients.
- **Monitoring Conduits and Prostheses**: MRI is useful postoperatively to detect potential complications, such as conduit stenosis or prosthetic wear, allowing for timely intervention.

The main limitation of MRI is the requirement for patient immobility during scanning, which may necessitate sedation for children. Additionally, the presence of metal implants can complicate MRI imaging, requiring alternative imaging methods in such cases.

Heart Catheterization and Angiography

Heart catheterization is performed less frequently but remains an important method for assessing hemodynamic parameters, particularly in patients suspected of having pulmonary hypertension. Catheterization allows measurements of pressures in various heart chambers and vessels and helps determine resistance in pulmonary vessels. This method provides the following information:

- **Pulmonary Artery Pressure Assessment**: Elevated pressure may indicate pulmonary hypertension, influencing the choice of surgical treatment.
- **Anatomical Angiography**: During catheterization, angiography with contrast dye visualizes the coronary arteries, pulmonary vessels, and aorta, helping to detect

vessel anomalies and plan interventions, such as stent placement in cases of stenosis.

- **Interventional Procedures**: Catheterization can also be used to expand narrowed vessels or place stents if blood flow is obstructed.

Although invasive, catheterization is often essential for precise preoperative planning and vessel condition assessment when other methods fail to provide sufficient information.

Genetic Testing and Additional Studies

Since CAT may be associated with genetic anomalies, such as a 22q11.2 deletion (DiGeorge syndrome), genetic testing is often recommended for patients. This testing evaluates inheritance risks and identifies accompanying genetic factors that could affect prognosis and treatment strategies. Additional laboratory studies may also be conducted to assess the condition of other organs and systems before surgery.

Diagnosing CAT requires the use of multiple imaging methods to obtain a complete picture of the heart and vessel condition. Echocardiography is the primary method for initial diagnosis and postoperative monitoring. CT and MRI offer detailed data on anatomical and functional blood flow parameters, especially useful for preoperative planning. Heart catheterization, although used less often, is essential for pressure assessment and interventional procedures when necessary. This comprehensive approach minimizes risks and enhances surgical outcomes [31, 55, 59].

Surgical Treatment

The surgical treatment of common arterial trunk is aimed at addressing hemodynamic abnormalities, separating systemic and pulmonary blood flow, and restoring the normal structure of the heart and major vessels. Early complete surgical correction in neonatal or infancy stages is considered the "gold standard" for treating this defect. This intervention reduces the risk of severe pulmonary hypertension and other complications that are inevitable with conservative management [1, 3, 5, 9, 49, 50, 55, 59]. The main goal of surgery is to create two separate pathways for blood circulation and eliminate the interventricular septal defect, significantly improving the patient's quality of life and reducing the risk of complications in the future [59, 61, 62, 63, 64].

Historical Overview of Treatment Methods

Before the introduction of complete correction methods for CAT, palliative surgery was the primary treatment method. This approach included banding the pulmonary arteries to reduce pulmonary blood flow, temporarily alleviating the patient's condition but not providing long-term improvement. Palliative operations were performed in cases where the patient's condition did not allow for complete intervention, or where the complete intervention was technically challenging [7, 8, 9, 19, 21, 22, 23]. However, high risks of complications and limited long-term outcomes made palliative surgeries undesirable, and they are now used only in rare cases when radical correction is not feasible.

In the mid-1980s, advancements in cardiac surgery enabled the first successful complete correction of CAT in newborns, marking a turning point in the treatment of this defect. Since then, the methodology and techniques of the operation have undergone significant changes to increase intervention success and minimize postoperative complications [10, 12, 28, 29, 68, 69].

Modern Surgical Methods

Modern approaches to the surgical correction of CAT involve early intervention, typically performed within a few weeks or months of life. The surgery aims to fully separate pulmonary and systemic blood flows and correct all anatomical defects associated with the defect [13, 15, 16, 24, 32, 71].

Main Stages of Surgical Correction

1.**Closure of the Ventricular Septal Defect (VSD):** A key step of the operation is the closure of the VSD, which is present in nearly all patients with CAT. This defect is usually closed using a patch made from the patient's pericardium or synthetic material. Closing the VSD prevents blood mixing between the left and right ventricles, necessary for restoring normal blood flow and preventing hypoxia of organs and tissues [16, 18, 34, 35].

2.**Reconstruction of the Right Ventricular Outflow Tract (RVOT):** After closing the VSD, the surgeon reconstructs the RVOT, creating a separate path for pulmonary blood flow. A conduit connecting the right ventricle to the pulmonary arteries is used for this purpose, which can be made from various materials, including biological or synthetic prostheses. Biological conduits (e.g., from human or animal tissue) have high biocompatibility, but their lifespan is limited, especially in children, requiring replacement as the patient grows [14, 15, 68, 70, 73].

3.**Reconstruction of the Common Arterial Trunk:** After creating the pulmonary pathway, the surgeon proceeds to reconstruct the common arterial trunk to ensure normal systemic blood flow. This involves removing the pulmonary arteries' orifice from the common trunk and creating a direct pathway for aortic blood flow. The common trunk's vessel wall usually requires reinforcement with patches to ensure normal aortic functionality and prevent the development of stenosis and other complications [42, 44, 71, 72].

4.**Valve Repair or Replacement:** The common trunk valve is often underdeveloped or has significant regurgitation, necessitating further correction. Minor defects may allow for valve repair to improve its function. In more severe cases, when the valve is fully dysfunctional, it is replaced with a prosthesis, which may be biological or mechanical, depending on the patient's age, degree of damage, and material availability [32, 35, 36, 37, 43].

Choice of Materials for Conduits and Valves

One important aspect of surgical correction of CAT is the choice of suitable materials for conduits and valves. Biological materials, such as homograft's (donor tissues) and xenografts (animal tissues), have good biocompatibility and can reduce the risk of thrombosis [43, 49, 50]. However, their lifespan is limited, especially in children, and they are prone to calcification and wear. Synthetic materials, such as polytetrafluoroethylene (PTFE), are less prone to calcification and have a longer service life but require anticoagulants to prevent thrombosis. The use of bioresorbable materials that adapt to a child's growth is a promising area of development, although these technologies are still in the early stages [37, 44, 48, 73].

Risks and Complications

The surgical treatment of CAT carries a range of risks and complications, depending on the technical aspects of the operation and the patient's overall condition [2, 6, 23]. The most common complications include:

- **Thrombosis and Thromboembolism:** Conduits and prostheses are at risk of thrombus formation, especially when synthetic materials are used. Patients are often prescribed anticoagulants to prevent thrombosis, although their use may be limited due to bleeding risk, particularly in children.
- **Infectious Complications:** Infection of surgical wounds or prostheses is a serious complication that can lead to sepsis and requires long-term antibacterial therapy. Antibiotics and strict control of sterility help reduce the risk of infection.
- **Pulmonary Hypertension:** Patients with CAT may develop pulmonary hypertension due to pulmonary blood flow overload, complicating the postoperative period and requiring vasodilators and other medications to stabilize the condition.
- **Valve and Conduit Dysfunction:** As conduits and prosthetic valves are subject to wear and calcification, dysfunction may arise over time, necessitating regular monitoring and replacement as needed. The rate of reoperations remains high for CAT patients, especially among children who grow quickly and need larger prostheses and conduits as they age.

Early Neonatal Correction

Early complete defect correction is preferable, as it prevents irreversible changes in pulmonary vessels and other organs. In the neonatal period, surgery can be technically challenging due to the small size of the heart and vessels but provides the best long-term results. Early correction also minimizes the risk of severe pulmonary hypertension and related complications [41, 50, 64, 67].

Postoperative Monitoring and Support

After surgery, patients require intensive monitoring and specialized care, especially in the first weeks following the intervention. Intensive care methods, such as nitric oxide inhalation and extracorporeal membrane oxygenation (ECMO) in cases of respiratory or heart failure, are used. Postoperative medication often includes heart and lung function support, blood pressure control, and thrombosis prevention [7, 11, 12, 14, 15, 22, 23, 31, 39, 52, 58].

In addition, regular imaging methods such as echocardiography, CT, and MRI are used to assess the condition of prostheses, conduits, and valves, as well as to detect possible complications at early stages [18, 19, 20, 21, 24, 25, 28]. Many CAT patients require reoperations during their lifetime, making postoperative monitoring a crucial component of successful treatment [60, 64, 65, 67].

Prospects for Improving Surgical Treatment

With technological advancements, new methods and materials are emerging that could significantly improve CAT surgical outcomes. One promising area is using 3D printing to model complex cases and create individualized conduits and prostheses. These technologies help surgeons better prepare for surgery and minimize complications. Another promising area is the development of biocompatible and growing conduits that can adapt to the child's growth, reducing the need for reoperations [11, 18, 41, 60, 64]. Research is also underway in gene and cell therapy to improve tissue regeneration and adaptation processes, which could significantly increase implant longevity and improve patient outcomes.

Thus, surgical treatment of common arterial trunk is a complex process that requires highly qualified specialists, modern materials, and constant monitoring. Modern methods significantly improve patient prognosis for this defect, but risks and complications require attention [2, 6, 45, 46, 57, 58, 67]. As technology develops and new methods emerge, CAT patients will have more opportunities for a full life with minimal post-treatment consequences.

Long-Term Outcomes and Patient Follow-Up

Long-term follow-up for CAT patients is an integral part of treatment. After the primary surgery, various complications may arise, such as prosthetic valve dysfunction, pulmonary artery stenosis, and the development of pulmonary hypertension. The most common complications include valve insufficiency progression and conduit dysfunction, requiring periodic updates.

Regular imaging studies, such as echocardiography, MRI, and CT, allow for assessing heart and vessel conditions, detecting early-stage complications, and preventing their further development. In some cases, catheterization may be needed for interventional procedures such as stent placement or stenosed vessel dilation [19, 21, 32, 48, 50, 53, 56, 58, 65]. CAT patients should also be monitored by a cardiologist throughout their life, as there is a risk of late complications, including pulmonary hypertension and prosthesis wear.

In recent years, the use of 3D technologies, such as 3D printing, has been actively developing to model complex cases and prepare for operations. These technologies help surgeons better plan interventions and assess heart anatomy, increasing accuracy and reducing complication risk [30, 33, 36, 39, 41, 56]. In addition, new interventional cardiology methods and improved materials for prostheses and conduits also contribute to better long-term outcomes.

Conclusion

The common arterial trunk is a rare and complex congenital heart defect that requires early diagnosis and a specialized treatment approach. The prognosis for patients with this defect is significantly improved by modern diagnostic methods and surgical treatment. Despite advancements in cardiac surgery and diagnostics, the common arterial trunk remains a challenging medical issue due to its anatomical variability, the need for lifelong monitoring, and potential complications that may necessitate repeat interventions.

The defect classification systems proposed by Collett and Edwards, as well as Van Praagh, allow cardiac surgeons to better plan treatment by taking into account the location of the pulmonary arteries and the anatomical features of the common arterial trunk. Each classification emphasizes different aspects of the defect's morphology, supporting an individualized approach to treatment and enhancing the success rate of surgical interventions.

Diagnostic methods such as echocardiography, computed tomography, magnetic resonance imaging, and catheterization play a crucial role in accurate visualization of the heart and major vessels. Echocardiography remains the primary method for both diagnosis and monitoring, enabling detection of structural abnormalities and assessment of the

heart's condition postoperatively. Computed tomography and magnetic resonance imaging provide high-quality imaging, especially valuable in complex cases and for long-term follow-up. Catheterization helps evaluate the functional status of the heart and blood vessels, particularly when hemodynamic parameters and pulmonary pressure information are required.

Surgical treatment of the common arterial trunk aims to separate pulmonary and systemic blood flow and to correct anatomical defects. The main steps of surgery include closing the ventricular septal defect, reconstructing the right ventricular outflow tract, and restoring aortic blood flow. The use of conduits and prostheses facilitates the establishment of a functionally complete circulation; however, it requires regular follow-up due to possible material wear and the need for replacements as the patient grows.

Long-term follow-up for patients with a common arterial trunk is essential due to their susceptibility to complications such as pulmonary artery stenosis, prosthetic valve dysfunction, and pulmonary hypertension. Modern imaging methods, including magnetic resonance imaging and echocardiography, allow for timely detection and correction of emerging issues, thereby enhancing the quality of life and survival rates for these patients.

In conclusion, managing patients with a common arterial trunk requires a comprehensive and individualized approach, starting with early diagnosis, the application of high-precision imaging techniques, and continuing with long-term postoperative follow-up. With further advancements in technology, such as 3D printing, improved prosthetic materials, and expanded genetic diagnostic capabilities, there is potential to improve the prognosis and quality of life for patients with this complex congenital defect.

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