Vasilii Ivanovich Kolesov: pioneer of coronary surgery

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BACKGROUND

Cardiovascular pathologies cause the highest mortality rate in adult populations, and one of the most serious among them is the ischaemic heart disease (IHD). In the 20th century, many therapists and surgeons put much effort to combat this disease. Among them was Vasilii Ivanovich Kolesov, who made a significant contribution to the field of coronary surgery.

By 1964, when the clinic led by V.I. Kolesov performed the first internal thoracic artery (ITA) coronary artery bypass grafting (CABG), the clinic already had an experience of indirect myocardial revascularization: over 300 patients were operated on using the Fieschi operation technique (ITA ligature), and over 20 using Vineberg-operation-based surgeries (ITA implantation into the myocardium). However, many surgeons and therapists were not satisfied with indirect myocardial revascularization, and many different laboratories worldwide were getting ready for the development of the direct approach. V.I. Kolesov conducted experiments on animals to create a highly efficient anastomosis between ITA and coronary arteries, prior to its clinical performance in the Academician I.P. Pavlov Leningrad Medical Institute 1.

On 25 February 1964, V.I. Kolesov successfully performed the first anastomosis between the left ITA and the left circumflex artery. This was the beginning of a new era of coronary bypass surgeries, carried out on a regular basis to re-establish coronary flow in patients with IHD. Twenty years later, this operation, in combination with René G. Favaloro’s method of using the saphenous vein in coronary surgery (1967), became the most commonly performed surgical procedure in the world.

It is noted that 25 and 10 years ago, A.S. Olearchyk and I. E. Konstantinov described the importance of V.I. Kolesov’s achievements in coronary surgery [1–4], respectively. On the occasion of the 50th anniversary of the ITA-CABG, we are publishing some well-known and new data about this great surgeon.

BIOGRAPHICAL NOTES OF V.I. KOLESOV

The future author of coronary bypass surgery was born on 24 September 1904 in the village of Martemianovskaya in the Vologda Region. In 1927, he was admitted to the State Institute of Medical Knowledge (current name: I.I. Mechnikov North-West University) and completed the medical programme. It was in his student years that V.I. Kolesov first showed an interest in research, and he joined the student biology society, guided by Pyotr Pavlovich Ivanov, a future prominent embryologist. In 1931, the young doctor V.I. Kolesov was assigned to work in the local hospital in the village of Chusovaya in the Perm territory (northern part of the Ural mountains). Then, in 1934, V.I. Kolesov was admitted to work in the surgery ward of the clinic at the Perm Medical Institute as an attending doctor under Vasilii Nikolaevich Parin (1877–1947), an intelligent and enthusiastic scientist in charge of the ward. In 1938, he received his Master’s degree in surgery from the Leningrad Institute of Postgraduate Medical Studies, shortly after he successfully defended his thesis ‘On eventration of spleen into the abdominal wound’.

In 1941, during the Second World War, V.I. Kolesov kept working as a surgeon in Leningrad. However, his health condition was deteriorating during the 900-day siege of Leningrad, so that he was unable to work until 1942. He returned to the surgical service as a senior surgeon, working in the military evacuation hospital, right after his recovery.

In 1946, V.I. Kolesov received an employment offer from Pyotr Andreieievich Kuprianov (1893–1963), who had been appointed head of the 2nd Faculty Surgery Clinic of the Military Medical Academy in 1945. V.I. Kolesov defended his doctorate dissertation on bacteriologic control and septic wound treatment with bacteriophage in 1946 and then left for Austria on a long-term business mission to be in charge of the surgery service of the advancing Central Army Group in 1949. Thereafter, he was appointed chief of the battle-field surgery department in Kharkov (Ukraine), from where he moved back to Leningrad 18 months later to lead the general surgery department. In 1955, he became head of the Faculty Surgery Clinic of the Academician I.P. Pavlov Leningrad Medical Institute 1. It was here that V.I. Kolesov’s teaching and research talents became obvious and he performed the first coronary bypass operation, which made it possible to refer to V.I. Kolesov as the coronary surgery pioneer (Figs 1 and 2) [1].

WORK IN THE FACULTY SURGERY CLINIC

V.I. Kolesov was a man of broad scientific vision and interest. He displayed an extensive knowledge and practice in general surgery,
and his contributions in surgical research were presented at sym-
possiums, conferences, congresses and meetings of the Pirogov
Surgical Society. In 1955, when he became head of the Faculty
Surgery Clinic, one of the major surgical clinics in the Soviet
Union, his major clinical focus was on myocardial blood flow and
surgical treatment of cardiac coronary disease (Fig. 3).

When looking for a solution to a difficult problem—re-establishment
of coronary blood flow—V.I. Kolesov studied all available USSR and
foreign language publications. This resulted in a book publication
in 1966, presenting a detailed encyclopedia-type description of
the worldwide history of IHD surgical treatment targeting indirect
myocardial revascularization [5].

Studies of the coronary flow and its surgical correction com-
menced at the time of his work in the Faculty Surgery Clinic, and
operations on patients began. For example, by 1966, the Fieschi
operation, which was popular in the 1950s, was performed on 310
patients [5]. A further procedure, which was presented by the
Canadian surgeon Arthur Vineberg in 1946 and performed by
him on a patient in 1950, drew V.I. Kolesov’s attention. This
Vineberg operation was performed on 21 patients, in most of
them with positive outcomes [6].

Taking into consideration all previous developments in coron-
ary artery surgery, V.I. Kolesov focused on the work of those
experimentalists who made the most significant contributions to

Figure 1: V.I. Kolesov, 1964 (from the archive of the Faculty Surgery Clinic).

Figure 3: V.I. Kolesov’s round in the clinic in the company of A.N. Tsareva, the
ward chief doctor (from the archive of A.N. Tsareva).

Figure 2: The Faculty Surgery Clinic building dates back to 1904. It was in this building that the ITA-CABG was first performed (from the archive of V.I. Khnykina).
the development of coronary blood flow re-establishment using ITA. For example, Vladimir Demikhov in Moscow (1953) and Canadian surgeon Gordon Murrey (1953) independently of each other demonstrated anastomosis between ITA and the coronary artery in dogs, using the collapsible cannula (the Payr type) and non-suture technique [7–9]. They laid the foundation for experimental studies of dogs for re-establishment of coronary flow, using system arteries.

On 2 May 1960, Robert H. Goetz in New York was the first one to anastomose ITA and the right coronary artery (RCA) in a patient using tantalum rings. He reported this surgery in 1961 in an addendum to an article describing experiments on dogs, which he carried out in the late 1950s [10]. As a result of harsh criticism from his colleagues, R.H. Goetz never performed such an operation again [11].

Only large-scale experiments made it possible to clinically perform ITA-CABG in the hospital led by V.I. Kolesov. These experiments were carried out in the united-front manner with participation of most members of the clinic (L.V. Potashov, E.V. Kolesov, K.K. Tokarevich, V.A. Shelykhin and others). Active participants of this work were medical students and members of the student research society (V.M. Sedov, O.F. Kruglikova and others).

Having summed up the results of experiments on dogs aiming at the creation of suture anastomosis ITA-CABG, V.I. Kolesov would, out of two ITA-CABG anastomosis techniques (non-suture and suture), focus on the latter, trying to create a T-shaped anastomosis allowing a natural coronary flow; it was the type of anastomosis for clinical practice. On 25 February 1964, the CABG operation was first performed by V.I. Kolesov. Here is the surgical record. Thoracotomy performed on the left, in the fifth intercostal segment. ITA mobilized together with adjacent tissues from level V of the costal-cartilage upwards, almost to the setoff of the artery pericardiacophrenica. Calcification was observed in the initial parts of the anterior interventricular and circumflex branches of the left coronary artery. The part of the circumflex artery with the calcification was selected and a tourniquet placed under it. The artery was gently pinched during 8 min. During all this time heart function did not change, and the arterial pressure remained stable. Electrocardiography (ECG) showed no changes during the entire time of artery pinching. Based on the data, a conclusion was made about a permanent impairment of the blood flow in the selected artery and that it was possible to open it without causing fibrillation of the heart ventricles. The patient was carefully placed on his right side. The circumflex artery was of the loose type, one of its major branches was slashed. The patency of the artery peripheral section was preserved, the central blood flow interrupted and the end-to-end anastomosis created. The anastomosis was carried out with a magnifying glass using the suture technique. Pulsation in the peripheral section of the anastomosed artery restarted. Loose stitches on the pericardium were performed. The wound on the chest was closed completely. The postoperative period was without complications. The patient did not display any IHD symptoms, and he was followed up for several years.

**THE DIRECT MYOCARDIAL REVASCULARIZATION ERA**

Since 1964, coronary flow re-establishment procedures had been performed on a regular basis. This was the beginning of the direct myocardial revascularization era. In 1967, The Journal of Thoracic and Cardiovascular Surgery published V.I. Kolesov’s article ‘Mammary artery-coronary artery anastomosis as method of treatment for angina pectoris’. The article presented data about 6 patients who had ITA-CABG surgery with the suture anastomosis technique. The addendum reads that by the time of publication, 12 such surgeries had been performed [12].

**APPLICATION OF VASCULAR STAPLERS**

The first ITA-CABG surgeries were performed by V.I. Kolesov off-pump without extracorporeal circulation, as, in the doctor’s opinion, ‘for patients in a grave condition, the assisted extracorporeal circulation is a serious aggravating factor, and it should be avoided’ [13]. However, in case of cardiac decompensation, especially in the event of acute myocardial infarction, assisted extracorporeal circulation is a life-saving procedure allowing necessary haemodynamic support before the restart of the coronary flow [13]. As a rule, in case of operations on the left anterior descending artery (LAD) and the RCA, assisted circulation was applied. Most of the scheduled surgeries on LAD were carried out off-pump. At that time, stabilization of the coronary artery was carried out using clamps (brackets) placed under the coronary artery (myocardial stabilizers will only have been developed and put into clinical practice 20 years later). Therefore, application of staplers in the end-to-end anastomosis was a logical solution ensuring the best surgical outcome. Modification of the mass-produced stapler ASTs-4 at the account of vacuum opening of the stitched vessels significantly improved the core stage of the surgery, the opening of arteries, which helped to achieve good clinical results, both immediate and long term [14].

**CORONARY ARTERIOGRAPHY**

First surgical procedures were carried out by V.I. Kolesov without coronary arteriography diagnostics. In his time, the Academician I. P. Pavlov Leningrad Medical Institute 1 just started using them. The first aortograms in patients with heart defects having non-selective filling of coronary arteries and semi-selective coronaryangiography did not provide a complete picture of coronary artery atherosclerosis. To improve the coronary angiogram quality, the technique of short-time heart function interruption was applied using acetylcholine (developed by Arnulf in 1958), followed by cardiac rhythm resuscitation at the account of electrocardiostimulation by means of an electrode inserted into the right ventricle. The first coronary arteriography that employed this technique was performed by L.V. Potashov in 1964 [15, 16]. Later, the technique was upgraded by E.V. Kolesov in the Military Medical Academy [5, 13]. Selective coronary arteriography using the Sones and the Judkins techniques allowed not only the diagnosis of the localization and degree of the coronary artery pathology but also identification of a coronary artery section with minor or no atherosclerosis pathology, which could be used for an anastomosis (E.V. Kolesov, T.A. Sulling and S.D. Astafeiva) [17].

**EPICARDIAL AND MOSAIC ELECTROCARDIOGRAPHY**

The necessity to register changes in the myocardial blood circulation in a certain zone led to the development of the epicardial ECG technique: recording of the unipolar lead from the
of the mammary-coronary anastomosis behaviour during the subsequent postoperative period allowed monitoring performed: before and immediately after the operation, and upper abdominal area. The record of the electrocardiotopogram leads of a surface ECG on the chest front and back and in the (E.V. Kolesov and N.G. Volodkovich), which uses over 100 unipolar Kolesov suf

dium to an ischaemia episode in the event of a subsequent anasto-
to the coronary blood-

off-pump heart surgery, we not only assess the degree of tolerance with vena saphena magna transplantation). Suture connection end-to-end

Leaving the electrode in place during the postoperative period allows better focused control of the re-established blood supply in the absence of changes on the epicardial ECG. Leaving the electrode in place during the postoperative period allows better focused control of the re-established blood flow than in the case of surface ECG.

Testing of the coronary artery pinching was not interpreted by V.I. Kolesov as preconditioning, although today, in case of an acute myocardial infarction; ASC-v: vacuum modification of ASC-4-stapler.

<table>
<thead>
<tr>
<th>Date</th>
<th>Procedure</th>
<th>Stapler</th>
<th>Access</th>
<th>CPB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic IHD</td>
<td>ITA-coronary (branch of LCx artery suture end-to-end anastomosis)</td>
<td>No</td>
<td>Thoracotomy</td>
<td>No</td>
</tr>
<tr>
<td>25.02.64</td>
<td>ITA-LAD suture end-to-side anastomosis</td>
<td>No</td>
<td>Thoracotomy</td>
<td>No</td>
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<tr>
<td>26.01.65</td>
<td>First stapler-facilitated ITA-LAD anastomosis</td>
<td>ASC-4</td>
<td>Thoracotomy</td>
<td>No</td>
</tr>
<tr>
<td>10.06.69</td>
<td>Double IMAS anastomosis</td>
<td>ASC-4</td>
<td>Thoracotomy</td>
<td>No</td>
</tr>
<tr>
<td>21.01.71</td>
<td>Aorta-RCA bypass with auto-artery (A. femoralis superficialis was substituted with vena saphena magna transplantation). Suture connection end-to-end</td>
<td>ASC-v</td>
<td>Thoracotomy</td>
<td>No</td>
</tr>
<tr>
<td>16.06.71</td>
<td>Aorta-RCA auto-vein bypass</td>
<td>No</td>
<td>Sternotomy</td>
<td>Yes</td>
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<tr>
<td>22.01.71</td>
<td>Aorta-RCA auto-vein bypass</td>
<td>ASC-4</td>
<td>Sternotomy</td>
<td>Yes</td>
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<tr>
<td>Acute IHD</td>
<td>ITA-LAD suture end-to-end anastomosis</td>
<td>No</td>
<td>Thoracotomy</td>
<td>No</td>
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<td>05.02.68</td>
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<td>No</td>
<td>Thoracotomy</td>
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<tr>
<td>11.02.72</td>
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<td>ASC-v</td>
<td>Sternotomy</td>
<td>No</td>
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<tr>
<td>28.01.75</td>
<td>AMI with pulmonary oedema. ITA-LAD anastomosis</td>
<td>ASC-v</td>
<td>Sternotomy</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Based on materials provided by Kolesov [19].

IHD: ischaemic heart disease; ITA: internal thoracic artery; LCx: left circumflex artery; LAD: left anterior descending artery; RCA: right coronary artery; AMI: acute myocardial infarction; ASC-v: vacuum modification of ASC-4-stapler.

epicardium of the left ventricle zone, subject to revascularization. Attachment of the epicardial electrode to the epicardial fat ensures a stable epicardial ECG (attachment to the cardiac muscle registers failure currents in the form of a monopolar curve with the ST segment elevation), which is sensitive to the zone blood supply. Testing of the coronary artery by pinching for 5-8 min, allows checking for the safety of the operation on the pinched coronary artery, in the absence of changes on the epicardial ECG. Leaving the electrode in place during the postoperative period allows better focused control of the re-established blood flow.

Testing of the coronary artery pinching was not interpreted by V.I. Kolesov as preconditioning, although today, in case of an off-pump heart surgery, we not only assess the degree of tolerance to the coronary blood-flow blockage but also prepare the myocar-
dium to an ischaemia episode in the event of a subsequent anasto-

mation formation.

As the standard ECG with 12 electrocardiogram leads was not sufficient for evaluation of the heart blood circulation, V.I. Kolesov’s co-workers developed the technique of mosaic ECG (E.V. Kolesov and N.G. Volodkovich), which uses over 100 unipolar leads of a surface ECG on the chest front and back and in the upper abdominal area. The record of the electrocardiotopogram performed: before and immediately after the operation, and during the subsequent postoperative period allowed monitoring of the mammary-coronary anastomosis behaviour [18-20].

AUTO-ARTERY BYPASS GRAFT

Studies of materials that would be best for coronary artery plasty with patch were carried out in the course of experiments on dogs. Out of the studied patches of auto-vein, auto-artery and auto-pericardium, the best survivability factor in case of coronary artery patch plasty was the auto-artery wall. V.I. Kolesov recommended making an ITA-based anastomosis with the coronary artery and the surrounding tissues, in order to pre-
serve the artery wall in most comfortable conditions.

Surgeries, in which splenic gastroepiploic, surface femoral arter-
ies were used for the anastomosis with the anterior interventricu-
lar artery (with replacement of the used sections by an auto-vein) were performed on dogs, to substantiate and develop techniques for selection and use of such arteries for myocardial revascularization [13, 19-22]. Not all experimental results were later put into clinical practice.

On 9 May 1967, René G. Favaloro performed the first CABG using the saphenous vein graft (SVG), in the Cleveland Clinic [23, 24]. After the positive experience with CABG surgery with SVG in this clinic, other medical institutes followed, resulting in the growth of this practice, and for a while it shaded the auto-arterial coronary bypass using ITA. However, long-time monitoring of patients after CABG in the 1970s–80s showed that the auto-arterial graft technique ensured a more stable and durable effect on the coronary blood flow re-establishment, and application of ITA remains in the leading position. V.I. Kolesov actively maintained the idea of auto-arterial bypass grafting, although in practice, he also used an auto-vein in CABG.

ACUTE CORONARY SYNDROME

Successful surgeries were performed by V.I. Kolesov in 1968 at the initial stage of myocardial infarction in the form of ITA-CABG [13]. The first patients were the ones who were getting ready for a scheduled operation of coronary flow re-establishment and who developed an acute myocardial infarction condition, becoming an urgent-surgery case. The first 2 patients had a suture anastomosis ITA-LAD, and the third patient had a stapler anastomosis ITA-LAD
using the ASTs-4 stapler. All 3 patients survived. The key to success was fast revascularization. This was the conclusion made by K.K. Tokarevich, who, under V.I. Kolesov’s guidance, performed several experimental surgeries on dogs using acute myocardial infarction simulation. Prompt re-establishment of coronary blood flow reduced the area of myocardial infarction, and at the same time the means of blood flow re-establishment did not matter much: it was either the removal of a previous ligature or mammary-coronary anastomosis. Today, this is the main principle in the treatment of patients with acute myocardial infarction: coronary blood flow re-establishment in the form of early thrombolysis, urgent coronary angioplasty or coronary bypass—all of them allow both saving the patient and preservation of most of the myocardium damaged by ischaemia. Re-establishment of the coronary blood flow can help even after a patient’s recovery from apparent clinical death, followed by anastomosis surgery ITA-LAD [13].

V.I. Kolesov was not a defender of multiple coronary bypass. He considered re-establishment of blood flow in the two coronary basins necessary in case of their occlusion or sub-occlusion of proximal arterial segments: ‘We re-established main blood flow in the two main coronary arteries by placing two mammary-coronary anastomoses by creating a mammary-coronary anastomosis and auto-vein aorta-coronary bypass. Surgical treatment here is based on the general surgery principle – to restore anatomical changes to their original condition as much as possible’ [13].

Today, there is hardly any clinic in the world that does not perform the Kolesov operation, which is the CABG procedure. The best variant of the anastomosis (ITA-LAD) is the suture anastomosis, just as it was 50 years ago. A minimally invasive access and an off-pump procedure are surgically less destructive and can be an option in case of LAD occlusions. These are the ideas that V.I. Kolesov espoused in his book The Surgery of Coronary Arteries of the Heart [13], which summarizes the first period of coronary surgery.

Upon retirement, V.I. Kolesov wrote a book called An Old Surgeon’s Notes [25], in which he critically described his life as well as his self-establishment as a surgeon and his path to coronary surgery, which was quite rocky and not always in line with the thinking and gratitude of his contemporaries. He died on 2 August 1992, and An Old Surgeon’s Notes was not published in his lifetime.

The book was published by V.I. Kolesov’s co-workers 9 years after his death. A major part during the publication was played by Vera Yakovlevna Pikaleva, an assistant professor at the Faculty Surgery Clinic.

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