

BIOGRAPHY ΒΙΟΓΡΑΦΙΑ

The Seldinger technique – the vascular access method Nephrology application

The Swedish radiologist Sven Ivar Seldinger (1921–1998) was born in Mora, a small town in northern Sweden. Following the completion of his medical studies at the Karolinska Institute in Stockholm, he started his career at the Department of Radiology, Karolinska University Hospital in 1950. His special interest was angiography. In those days, the intravascular administration of contrast media involved catheterisation after a surgical incision of the vessels, either through a small polyethylene catheter placed in the needle or by direct needle puncture. Complications were common and the contrast medium could only be injected relatively slowly. In April 1952, Seldinger had “a severe attack of common sense”. He realised the sequence in the procedure of catheter introduction to the vessel should be: needle in – guide-wire in through the needle – needle out – catheter in over the guide-wire – guide-wire out. This revolutionised the vascular access procedure and became widely used in interventional radiology, as well as in other clinical applications in Scandinavia and gradually spread to other clinical settings worldwide. Ever since the introduction of haemodialysis in the 1940s, vascular access had been the method’s “Achille’s heel”, especially as the need for dialysis was continuously increasing. The most important steps in the improvement of haemodialysis were the creation of the Quinton–Scribner shunt in 1960 and later the Cimino–Brescia arteriovenous fistula in 1966. However, an easy method of vascular access for acute therapeutic needs or investigation was missing. The Seldinger technique solved this problem and was unrivalled thanks to its simplicity, quickness, and low risk of complications. Stanley Shaldon introduced this technique in dialysis in 1961. Since then, it has been used for all extracorporeal procedures in dialysis departments, when no other vascular accesses are attainable. Seldinger used this method to perform many interventions, such as catheterisation of the renal artery and selective renal angiography (1955). He returned to Mora in 1966 and worked at the local hospital until his retirement in 1986.

1. EARLY YEARS

Sven Ivar Seldinger (fig. 1) was born on 19 April 1921 in the small town of Mora in the northern Swedish province of Dalecarlia. A member of his mother’s family worked with fine mechanics, making the famous Mora clocks. His great-grandfather, Djos Matts, while sitting in his Mora Mechanical Workshop, was painted (oil on canvas) by the renowned painter Anders Zorn in 1906 (fig. 2). Young Sven Ivar often visited his grandfather’s workshop and observed him as he used precision tools. He attended primary school in Mora and high school in the nearby town of Falun. As a 17-year-old

high school student, he went on a bicycle tour in Germany and sent a series of reports, which were published in the local Mora Newspaper, where, after graduating, he served for half a year as a volunteer. In 1940, he applied for technical and medical universities, was admitted to both but chose medical studies at the Karolinska Institute in Stockholm. After graduation in 1948, followed by an internship at hospitals in Stockholm, he obtained a residency in the Department of Radiology at Karolinska Hospital in 1950, where he joined the angiography group and assisted in the procedures.^{1,2} He quickly earned a reputation for being highly intelligent, independent and at times drastic in expressing himself.³

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ΑΡΧΕΙΑ ΕΛΛΗΝΙΚΗΣ ΙΑΤΡΙΚΗΣ 2020, 37(Συμπλ 2):57–62

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Η τεχνική Seldinger –
η μέθοδος αγγειακής προσπέλασης:
Νεφρολογική εφαρμογή

Περίληψη στο τέλος του άρθρου

Key words

Dialysis access
Interventional radiology
Seldinger technique



Figure 1. Sven Ivar Seldinger, 1950s (reproduced by permission of Seldinger's family).



Figure 2. Sven Ivar Seldinger's great-grandfather Dios Matts painted by Anders Zorn 1906. Reproduced by permission of the Zorn collections, Mora, Sweden.

2. RESIDENCY, DEPARTMENT OF RADIOLOGY, KAROLINSKA HOSPITAL, STOCKHOLM

At this time, the three main methods of blood vessel access for angiography were:¹⁻⁴

- Surgical incision to expose venous and arterial vessels

before catheterisation, often followed by resuturing or ligation of the vessel

- Percutaneous puncture using a needle with a catheter inside (catheter-through-needle) where small or large bore needles were used. In case of small calibre of the catheter the flow and amount of administered contrast was limited
- Direct needle-puncture of vessels (e.g. the carotid and femoral artery, the lumbar artery) and organs (the heart) and injection of contrast media through the needle.

These methods were relatively traumatic, time-consuming and involved a substantial risk of blood loss, damage to the vessel walls, nerves, infection and other complications. Some parts of the vascular bed like the visceral arteries were not accessible to investigation.

Technically oriented Seldinger was well aware of these disadvantages of the existing methods of vascular access. He intended to improve the catheter insertion technique and initially modified the Cournand's puncture method using an inner sharp needle in an outer blunt cannula, the edge of the needle exceeding the cannula by 1–2 mm.⁵ It was difficult to operate with the longer needle and Seldinger inserted the needle in the side hole of the catheter with the tip protruding 1–2 mm beyond the catheter end. After introducing the needle and the catheter into the vessel, the needle was removed and a piano string wire was inserted into the catheter to make it rigid enough to be pushed along the vessel (fig. 3). Later, the string was replaced by an actual guide wire (long semi-flexible metal wire tightly coiled on a central wire core) constructed in cooperation with Stille-Werner company in Stockholm. This method was, however, imperfect and one day in April 1952, during his second year of residency, when he was standing depressed at the table with the needle, guide wire and catheter in his hands, making several attempts to place a catheter into a frozen cadaver aorta,⁶ he was struck by what he himself described as a "severe attack of common sense". He realised that he should use these three items in another sequence (fig. 4): (a) Needle in; (b) guide wire in through the needle; (c) needle out; (d) catheter in over wire; (e) guide wire out.⁴ With "beginner's luck" he successfully used this new technique the following day in a brachial artery puncture to get access to the subclavian artery for visualisation of a parathyroid adenoma.⁷

3. SELDINGER TECHNIQUE ACCEPTED WORLDWIDE

In June 1952, the Seldinger technique was presented by his professor Knut Lindbom at the Nordic Association

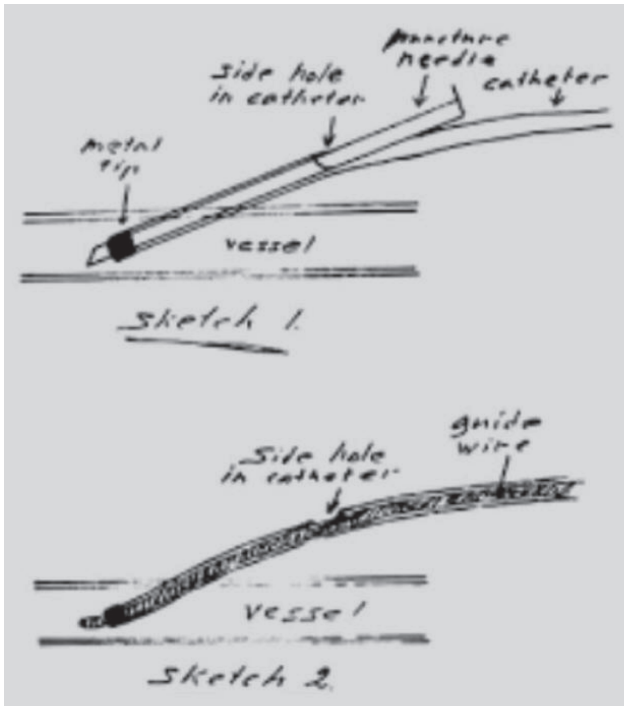


Figure 3. Seldinger's line drawings of two stages in the development of his method of introducing a catheter into an artery. Reproduced by permission from letter to Doby T., published in *AJR Am J Roentgenol* 1984, 142:2.

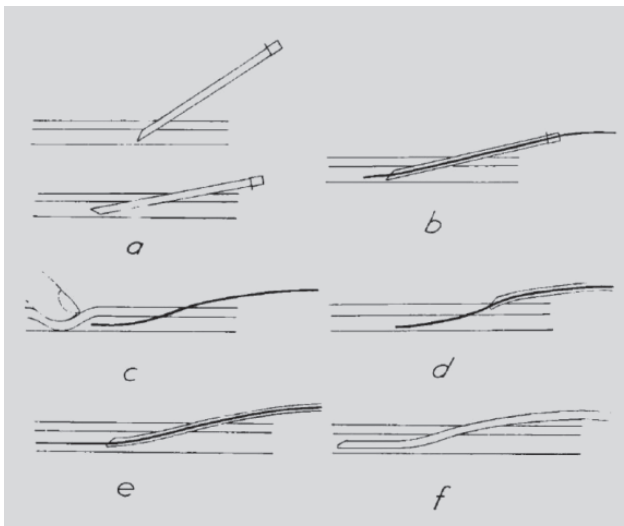


Figure 4. Steps in the Seldinger technique of vessels catheterization. Reproduced by permission from the original paper by Seldinger in *Acta Radiol* 1953, 39:370.

of Medical Radiology in Helsinki, Finland (Seldinger stayed in the hospital doing the routine work) and in 1953 it was published in *Acta Radiologica*.⁴ It described 40 cases of angiographies, without severe complications and proved to be a new method for quick, simple and easy access for

catheterisation of peripheral and central arterial and venous vessels. Seldinger wrote: "This technique is simpler than appears on paper and after a little practice should present no difficulties". The Seldinger technique was introduced in Sweden as early as 1952 and soon gained in popularity across Europe and later in the United States.

Seldinger showed on a cadaver's aorta that with his access technique all aortic branches could be catheterised by the femoral route⁷ and applied this method in many interventions, such as catheterisation of the renal artery and selective renal angiography (1955) using a pre-shaped bent polyethylene catheter of the same size as the needle or somewhat larger (fig. 5).^{8,9} He performed transhepatic and transsplenic catheterisations of the portal vein for venography and studies of hemodynamics, also for cholangiography via percutaneous puncture of the bile duct.^{10,11} The position, the course of the vessels and all pathological abnormalities, for example in extremities, could now be visualised.¹² This ingenious invention was a medical milestone, used widely in all interventional vascular and nonvascular procedures in radiology, neurology, oncology (arterial cytostatic treatment), urology and nephrology (haemodialysis treatment), cardiology and treatment of vascular diseases.^{13,14} The Seldinger technique fully contributed to the development of cardiovascular catheterisation (investigation of cardiac hemodynamics, coronary angioplasty, endovascular stent-graft placement). Courmand, Forssmann and Richards were awarded the Nobel Prize in Physiology or Medicine in 1956 for the work in this field.

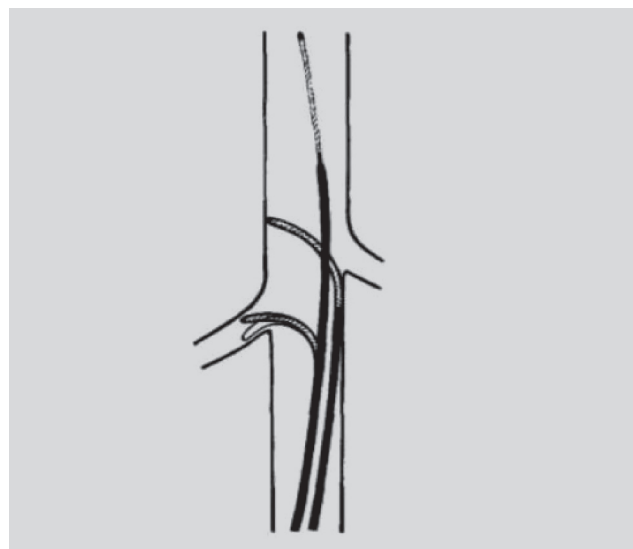


Figure 5. Steps in introducing a catheter into the renal artery (selective renal angiography). Reproduced by permission from *Acta Radiol* 1956, 45:16.

As estimated according to the number of sold guide wires, by 1984, this technique had been used in as many as 50 million patients up from just 6 million in 1983.¹⁵

4. THE SELDINGER TECHNIQUE IN NEPHROLOGY

Access to vessels in haemodialysis treatment had been an important problem since the early 1940s. Initially, only acute cases were treated and access to a peripheral artery and vein was obtained through exposure of the vessels and insertion of glass or plastic cannulae. After each treatment, the cannulae were removed and the vessels tied – consequently after several treatments the possibility to obtain access was lost.

In the late 1950s, when treatment of chronic renal failure started, the access problem became especially crucial as a patient needed to be connected to a dialyser over 100 (nowadays 150) times in one year. The situation changed in 1960 when the Quinton-Scribner arteriovenous shunt was introduced and further in 1966 when the Cimino-Brescia arteriovenous fistula was implemented. Both required simpler operative procedures and were inadequate in acute cases when haemodialysis had to be started immediately (due to e.g. hyperkalemia, overhydration, intoxication), in patients with failure of the existing accesses or waiting for access operation.

In 1961, Shaldon from London (UK), unable to find a surgeon to expose the vessels and insert a catheter for haemodialysis, used the Seldinger technique for placing catheters via the femoral artery and vein.¹⁶ He was also able to use femoral venous catheters for single or repeated dialyses in intermittent treatment when chronic haemodialysis was started in 1961. Currently, the Seldinger technique is an irreplaceable method of catheterisation in emergency access situations in many haemodialysis departments, especially those that deal with different forms of extracorporeal circulation. It takes about 20 minutes between the decision for catheter insertion via the femoral vein and connection to the proper machine.

In the Department of Nephrology in Lund, Sweden, this percutaneous access procedure for catheter insertion is used for haemodialysis, continuous arteriovenous (veno-venous) haemofiltration, haemoperfusion, plasmapheresis, protein A immunoabsorption and other extracorporeal procedures. The femoral veins may be used alternatively many times by an experienced person. The size of the double lumen catheter's internal diameters allows blood flow of up to 300 mL/min. A single lumen catheter with a smaller external diameter can be used in continuous

blood circulation if double pump equipment is available. Complications like bleeding or puncture of an artery may happen but nerve damage or femoral stenosis are very rare.

5. EPILOGUE

Sven Ivar Seldinger defended his doctoral thesis "Percutaneous Transhepatic Cholangiography" in 1966¹⁷ and moved to the Radiology Department at the University of Gothenburg where he got the position of Associate Professor. After spending one year there, he returned to his home town of Mora to become Head of the Radiology Department at the local hospital until his retirement in 1986 at the age of 65. He died 12 years later, on 21 February 1998 in his home in Mora. He was survived by his wife, an artist. They had three daughters.

Sven Ivar Seldinger published 32 clinical articles, eight of which refer to nephrology. Worldwide acknowledgement of Seldinger's contribution was proved by many awards and honours that he received. Herbert Abrams (a prominent radiology professor at the Harvard Medical School and the Stanford University School of Medicine, Nobel Peace Prize 1985), wrote: "...probably no single contribution has weighed more heavily than the technique developed by Sven Seldinger... His contribution moved the field into a new and exciting direction and left permanent imprint on medical imaging, diagnostic and therapeutic medicine".¹⁸ His close Swedish friend and colleague Torgny Greitz wrote: "We who know him learned soon to appreciate his sincerity, honesty, and solicitude for others. He was a good and reliable friend".³

His name is preserved in the Swedish Seldinger Society of Vascular and Interventional Radiology, established in 1992.

Honorary member: Central African Congress of Radiology, Bulawayo 1963; South African Congress of Radiology, Johannesburg 1968; International Radiology Congress, Madrid 1973; The New York Academy of Medicine, Section of Urology, New York 1975; The Angiography Course, Massachusetts General Hospital, Boston 1981; European Radiology Congress, Lisbon 1987; International Symposium of Interventional Radiology and New Vascular Imaging, Hakone, Japan 1988; International Radiology Congress, Paris 1989; The Atherectomy Symposium, Coronary Interventions, San Francisco 1990; The Annual Meeting of the British Society of Interventional Radiology, Sheffield 1991; Asian Oceanian Congress of Radiology, New Delhi 1992; Annual Meeting of the Society of Cardiovascular and Interventional Radiology, Washington DC 1992.

Honorary memberships: Swedish Society of Radiology,

1979; The American Society of Neuroradiology, 1986; The Radiological Society of North America, Chicago 1991; The American Society of Cardiovascular and Interventional Radiology, 1992; Seldinger Society of Vascular and Interventional Radiology, 1993; Swedish Society of Neuroradiology, 1993; Doctor Honoris causa – Uppsala University, 1984.

Awards: Valentine Award, New York Academy of Medicine, Section of Urology, for “distinguished contributions

to urology”, 1975; Korrespondierende Mitglied in Deutsche Röntgengesellschaft, 1976; Theodore and Jean Castle Professor of Radiology (the first holder of this professorship), Case Western University, Cleveland, Ohio USA, 1991; the first recipient of the “Pioneer in Interventional Radiology Award” by the American Society of Cardiovascular and Interventional Radiology, 1992; The Royal Swedish Academy of Science, Hilda och Alfred Eriksson award, 1993.

ΠΕΡΙΛΗΨΗ

Η τεχνική Seldinger – η μέθοδος αγγειακής προσπέλασης: Νεφρολογική εφαρμογή

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Ο Σουηδός ακτινολόγος Sven-Ivar Seldinger (1921–1998) γεννήθηκε στη Μόρα, μια μικρή πόλη στη βόρεια Σουηδία. Μετά την ολοκλήρωση των ιατρικών του σπουδών στο Ινστιτούτο Καρολίνσκα στη Στοκχόλμη, ξεκίνησε την καριέρα του στο Τμήμα Ακτινολογίας, στο Πανεπιστημιακό Νοσοκομείο Καρολίνσκα το 1950. Επέδειξε ιδιαίτερο ενδιαφέρον στην αγγειογραφία. Εκείνη την εποχή, η ενδαγγειακή χορήγηση σκιαγραφικών μέσων περιλάμβανε καθετηριασμό μετά από χειρουργική τομή των αγγείων, είτε μέσω ενός μικρού καθετήρα πολυαιθυλενίου τοποθετημένου στη βελόνα είτε με άμεση διάτρηση από βελόνα. Οι επιπλοκές ήταν συχνές και το σκιαγραφικό μέσο μπορούσε να εγχυθεί σχετικά αργά. Τον Απρίλιο του 1952, ο Seldinger είχε «μια σοβαρή επίθεση της κοινής λογικής». Συνειδητοποίησε ότι η ακολουθία στη διαδικασία εισαγωγής του καθετήρα στο αγγείο πρέπει να είναι: βελόνα μέσα – οδηγός-σύρμα μέσα από τη βελόνα – βελόνα έξω – καθετήρας μέσα πάνω από τον οδηγό-σύρμα – οδηγός-σύρμα έξω. Αυτό έφερε την επανάσταση στη διαδικασία αγγειακής πρόσβασης και χρησιμοποιήθηκε ευρέως στην Επεμβατική Ακτινολογία, καθώς και σε άλλες κλινικές εφαρμογές στη Σκανδιναβία και σταδιακά εξαπλώθηκε σε άλλα κλινικά περιβάλλοντα σε όλο τον κόσμο. Από την εισαγωγή της αιμοκάθαρσης τη δεκαετία του 1940, η αγγειακή πρόσβαση ήταν η «αχίλλειος πτέρνα» της μεθόδου, ειδικά καθώς η ανάγκη για αιμοκάθαρση αυξανόταν συνεχώς. Τα σημαντικότερα βήματα στη βελτίωση της αιμοκάθαρσης ήταν η δημιουργία παροχέτευσης Quinton-Scribner το 1960 και αργότερα του αρτηριοφλεβικού συριγγίου του Cimino-Brescia το 1966. Ωστόσο, έλειπε μια εύκολη μέθοδος αγγειακής πρόσβασης για οξείες θεραπευτικές ανάγκες ή έρευνα. Η τεχνική Seldinger λύνει αυτό το πρόβλημα και ήταν απαραίτητη χάρη στην απλότητα, την ταχύτητα και τον χαμηλό κίνδυνο επιπλοκών. Ο Stanley Shaldon εισήγαγε αυτή την τεχνική στην αιμοκάθαρση το 1961. Από τότε, έχει χρησιμοποιηθεί για όλες τις εξωσωματικές διαδικασίες σε τμήματα αιμοκάθαρσης, όταν δεν είναι εφικτές άλλες αγγειακές προσβάσεις. Ο Seldinger χρησιμοποίησε αυτή τη μέθοδο για να εκτελέσει πολλές παρεμβάσεις, όπως ο καθετηριασμός της νεφρικής αρτηρίας και η επιλεκτική νεφρική αγγειογραφία (1955). Επέστρεψε στη Μόρα το 1966 και εργάστηκε στο τοπικό νοσοκομείο μέχρι τη συνταξιοδότησή του το 1986.

Λέξεις ευρητήριο: Επεμβατική Ακτινολογία, Παρακέντηση, Αιμοκάθαρση, Τεχνική Seldinger

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