

Sven Ivar Seldinger (1921-1998)

"Within the art and science of medicine, there are three major categories of technologic developments. First, the major breakthroughs: the stuff for which Nobel Prizes are awarded, such as Roentgen's original discovery of X-rays; second, the major technical developments that open up completely new clinical areas, such as Forssman's first catheterization on himself in Berlin 1929; and third, the practical manoeuvres or techniques that permit the successful clinical application of the foregoing more fundamental advances. Seldinger's contribution belongs to the third category and, like others of transcending significance; it continues to play a major role in the development of modern radiologic practice" (1).



Sven Ivar Seldinger (dry-point engraving by his wife Britt-Lis Seldinger, 1985)

Sven Ivar Seldinger was born and grew up in Mora, Dalarna, Sweden. On his mothers side there were many clockmakers manufacturing the famous Mora' clock. The bearded clockmaker Djos Matts, portrayed by Anders Zorn (1860-1920) was Seldinger's great grandfather and his grandfather had a precision-tool workshop, often visited by Seldinger during his boyhood which gave him a tradition in this art (2).



Djos Mats (Anders Zorn, oil on canvas 1906, reproduced by permission of the Zorn collections, Mora, Sweden)

Seldinger studied medicine at Karolinska Institute 1940-1948 and did his internship at Karolinska hospital and various other hospitals in Stockholm. In 1950 he started his residency in radiology at Karolinska hospital under the leadership of Professor Åke Åkerlund who was followed by Professor Knut Lindblom. Early on Seldinger had the opportunity to assist during angiographic procedure which made him interested in the technique (3).

Angiographic technique in the early 1950s
Stig Radner in Sweden had introduced catheter angiography of the vertebral, subclavian artery and thoracic aorta via exposure of the radial artery in the late 1940s (4-6). At the same time Gunnar Jönsson in Sweden performed thoracic aortography by introducing a coaxial needle into the common carotid artery, removed the inner cannula and introduced a silver thread with a blunt end. Using this thread as a guide the cannula was pushed into the aortic arch for contrast medium injections (7). In Germany, Euler (1949) performed thoracic angiography by puncturing the aorta through the oesophagus (8). In Cuba, Ponsdomenech and Beato-Nunez 1951 performed direct punctures of the heart to visualize the ventricular chambers (9). Carotid and vertebral angiographies by this time was also still performed by direct puncture of these arteries with contrast media injections through the needles, primarily introduced by the Portuguese pioneer Egaz Moniz 20 years earlier (10).

Angiography of the lower body was still performed via translumbar aortic puncture, introduced by Moniz collaborator dos Santos 1929 (11, 12), or by direct puncture of the femoral artery used by Åke Lindblom in his classical thesis on Atherosclerosis in the lower limb (13). Pedro Fariñas in Cuba performed catheter angiography of the abdominal aorta in 1941 by surgically exposing the femoral artery, puncturing it with a trocar and then introducing the catheter through a trocar (14). Bierman et al. reported in 1951 on visceral catheter angiography introduced after exposure of the carotid artery (15).

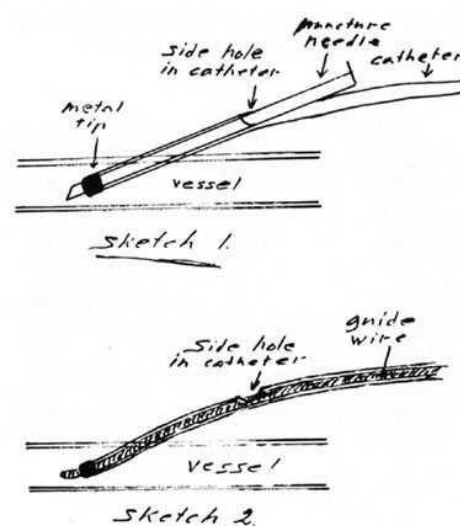
Following the introduction of the thin walled polyethylene catheter by Helmsworth,

McGuire and Felson* 1950 (16), Converse Peirce in 1951 was for the first time able to percutaneously puncture the femoral artery, introduce the catheter through the needle and obtain haemostasis after the procedure without surgery (17). Erik Lindgren used the same technique but to compensate for the low contrast medium flow through the thin catheters, blood pressure had to be lowered under full anaesthesia (18). According to the technically oriented Seldinger "it felt natural to find a way to use a thinner needle to reduce arterial trauma and a catheter of larger calibre to increase inner diameter and thereby higher injection rates" (2).

*Benjamin Felson, *The thoracic radiologist*.

Development of the Seldinger technique

Seldinger first thought of a puncture technique used by Cournand (Nobel prize winner 1956 with Forssmann and Richards for introducing heart catheterization) with a cutting needle, but replacing the outer cannula with a polyethylene catheter and using a short needle inserted through a side hole of the catheter located relatively close to the tip of the needle as the illustration demonstrates (3, 19):



Reproduced from Doby T. AJR 1984;142:1-3 (permission by AJR).

The needle punctured the skin and vessel wall and once the catheter was in place, Seldinger pushed it forward into the vessel and removed the needle. A few angiographies were performed with this technique. However, the polyethylene tube was not rigid enough to be push through the skin and the vessel wall without kinking. He therefore introduced a piano wire to stiffen the catheter. Shortly thereafter he participated in the construction of a metal spiral armed with a central core together with the company Stille-Werner, the modern guide wire was born. Still the technique was imperfect, with a possible risk of catheter break at the side-hole. After another failed attempt with the modified Cournand-technique, Seldinger one day stood depressed with the three items in his hand, the needle, the catheter and the guide wire. Then he was stroked by what he himself described as a *ösevere attack of common senseö*. Within a split of a second he realized how to use the three items: *needle in, guide-wire in through the needle, needle out, catheter in over the wire and finally removal of the guide wire*. This happened in April 1952.

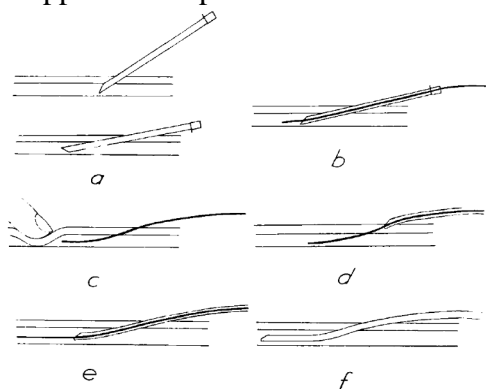


Fig. 2. Diagram of the technique used. a) The artery punctured. The needle pushed upwards. b) The leader inserted. c) The needle withdrawn and the artery compressed, d) The catheter threaded on to the leader. e) The catheter inserted into the artery. f) The leader withdrawn.

Copied from the original paper by Seldinger in Acta Radiol 1953:39:368-376 (by permission of Acta Radiol)

Seldinger tells that: "Already the next day the new technique was attempted. Following percutaneous puncture of the brachial artery

the catheter was advanced into the subclavian artery for parathyroid angiography and a mediastinal parathyroid adenoma, missed at previous surgery, was disclosed" (3). The Nordic Association of Medical Radiology was to start within a week in Helsinki, Finland, June 1952, and the deadline for submitting papers was far overdue. Seldinger, principally being only a two-year resident in radiology, was to stay home and do the routine work. Instead his chief, Professor Knut Lindblom, with Seldinger's permission presented the new technique (3). The invention was published in Acta Radiol 1953;39:368-376 with the title "*Catheter replacement of the needle in percutaneous arteriography - a new technique*".

Consequences

Seldinger's work was extensive and comprehensive. He showed on cadavers of the aorta that all aortic branches could be reached from the femoral route with an appropriately pre-shaped bend of the polyethylene catheter. He introduced selective renal arteriography and reported on parathyroid angiography. He also described transhepatic and -splenic catheterization of the portal vein and pioneered percutaneous transhepatic cholangiography with this technique.

The Seldinger technique spread quickly in Sweden and was in routine use in many hospitals before it was published in Acta Radiol. It became widespread in Europe just a few years after its publication, but took many years before it was accepted in the United States (19). When Seldinger in a radio interview 1993 was asked how his new technique was received he answered: *ö* It spread rapidly to all corners of the world

except for the nearby Seraphim Hospital in Stockholm which was next to Antarcticö (told by Torgny Greitz, Prof. in neuroradiology, Karolinska Hospital, in a personal letter to the present author). The X-ray Department at Seraphim Hospital was run by Professor Erik Lindgren (1905-2005), who used the Pierce trocar technique (see above).

The Seldinger technique laid the foundation for the development of all types of modern non-vascular and vascular diagnostic and interventional methods based on percutaneous catheterization. It enabled the development of e.g. selective coronary, cerebral, renal and mesenteric angiography, balloon angioplasty, endovascular stent and stent-graft placement, embolization, arterial cytostatic treatment, haemodialysis access, porto-systemic shunts as well as urinary and biliary interventions and abscess drainage.

Seldinger's career

Seldinger did several pioneering works including angiographic diagnosis of parathyroid adenoma, selective renal catheterization, and portal vein catheterization and pressure recordings via the spleen and liver. His thesis in 1966 was on "Percutaneous transhepatic cholangiography". Shortly thereafter he moved from Karolinska Hospital to Sahlgrenska Hospital, Gothenburg, but soon left the academic life and returned to his home town Mora. There he served as head of the Department of Radiology until his retirement 1986.

"A tribute to Sven Ivar Seldinger"

In the January issue of American Journal of Roentgenology, 1984, the 30 year anniversary of the Seldinger technique was celebrated with the following citations (20,

21):

T. Doby: "It is almost impossible to imagine life without things we grew up with, so it is a little hard for us to feel the thrill of angiographers when they first heard about the Seldinger technique. Present-day radiologists cannot even guess how angiography could have been done without it. We are so used to this method that we have begun dropping the eponym, as it has become the natural way to insert the catheter in a blood vessel".

Charles T. Dotter: "Simple events can have staggering consequences. Countless others have used, refined and developed his method without need for a significant alteration in its basic approach. Considering the number of catheter guides sold currently and over the intervening years, there is strong reason to believe his technique has by now served as many as 50 million patients. How many unnecessary cut downs, how many cold hands, how much pain and infection, have been avoided as the result of a moment's insight on his part?"

Ronald G. Grainger: "Still more important is the immense benefit to the patient that resulted from forgoing surgical incision and exposure in favour of a 3 mm needle hole that permits bloodless access to the entire cardiovascular tree and many abdominal viscera as well".

Herbert L. Abrams: In the movement of angiography from the part of a bit player to that of a protagonist in the scenario of diagnostic and therapeutic medicine, probably no single contribution has weighed more heavily than the technique developed by Sven Seldinger. To a major degree, its elegance and its usefulness lie in its very simplicity, and although Seldinger has been modest about his contribution, it took ingenuity and creativity

to lead angiography into a new period and a new arena".

Some records from the original paper

Seldinger writes: "The artery exposure technique of catheterization is time-consuming, troublesome and may present certain risks. The passage of a thin-walled polyethylene tube through a large bore needle may make puncture difficult and limits its use to comparatively large arteries. There is also extra damage to the artery and haemorrhage after removal of the needle may be troublesomeö.

öThere is a simple method, however, of using a catheter the same size as the needle and which has been used at Karolinska Hospital since April 1952ö.

Equipment (Supplied by AB Stille-Werner, Stockholm.)

- 1) A puncture needle with stilette.
- 2) A flexible rounded-end metal leader (i.e. guide wire) with increased flexibility of its distal 3 cm.
- 3) A polyethylene tube [No. 200: ID/OD 1.4/1.9 mm (ODé6 French); No. 205 ID/OD 1.57/2.08 mm (ODé6.5 F)], of the same diameter as the needle (2.0 mmé14 Gauge), with an adapter for the attachment of a syringe. The leader.....should be at least 8-9 cm longer than the catheter.

Technique

- a. After local anaesthesia, the artery is punctured percutaneously at a relatively small angle. After puncture it is best to rotate the needle 180° and push it a little into the artery using the bleeding as a guide to ensure that the needle remains in the artery (note that Seldinger only punctured

the front wall).

- b. The supple tip of the leader is inserted a very short distance into the lumen of the artery through the needle.
- c. The leader is held in place and the needle removed.
- d. The catheter is threaded on to the leader;
- e. The catheter and leader are gripped near the skin through which they are inserted.
- f. The leader is removed and the catheter directed to the level required,..... The unsupported catheter is usually pushed up the vessel without difficulty, but occasionally the leader must be re-introduced into the catheter in order to support it. The leader should not be passed beyond the tip of the catheter (contrary to modern technique).

The technique is simpler than appears on paper and after a little practice should present no difficulties".

In his original paper Seldinger reported 40 angiographies performed with the new technique, 35 aortographies, 3 subclavian and 2 antegrade femoral arteriographies. Two catheterizations failed but no serious complications occurred. Each contrast medium injection was made manually using 30 mL of 35, 50 or 70% solutions of diethanolamine 3,5-diiodo-4-pyridone-N-acetate acid (Umbradil®, Astra); 175-350 mg I/ml.

Seldinger Society of Vascular and Interventional Radiology

SSVIR in Sweden was constituted February 6, 1992, with the permission of Seldinger to use his name. At the annual meeting April 21, 1993, Seldinger was elected honorary member of SSVIR.

Awards of Sven Ivar Seldinger*Honorary member*

Central African Congress of Radiology, Bulawayo 1963.

South African Congress of Radiology, Johannesburg 1968.

International Radiology Congress, Madrid, 1973.

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 1991.

The American Society of Cardiovascular and Interventional Radiology, 1992.

Seldinger Society of Vascular and Interventional Radiology, 1993.

Swedish Society of Neuroradiology, 1993.

Doctor Honorius causa

Uppsala University, 1984.

Other 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 Case Western University, Cleveland, Ohio 1991.

Pioneer in Interventional Radiology Award, The American Society of Cardiovascular and Interventional Radiology, 1992.

The Royal Swedish Academy of Science, Hilda and Alfred Eriksson award, 1993

Thesis

Percutaneous transhepatic cholangiography. Acta Radiol Suppl 1966, vol. 253. Defended May 20, 1966, faculty opponent Åke Lindbom. Thereafter Seldinger became Associate Professor at the University of Gothenburg.

Publications by Sven Ivar Seldinger (partly obtained from his wife Britt-Lis Seldinger)

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