30. Vascular Surgery

Hans O. Myhre

The Pioneering Period
Professor Ragnvald Ingebrigtsen had, in 1910, studied vascular surgical technique at the Rockefeller Institute, New York, where he worked as a research fellow with Alexis Carrel (1873–1944). Ingebrigtsen made important contributions to the understanding of the hemodynamic consequences of arteriovenous fistulas. He took up these problems after having retired from the position as professor of surgery at Rikshospitalet, and made important experimental investigations even after he had passed the age of 80. Although Carrel through his experimental work developed the basic techniques for vascular surgery before 1910, his principles were not used in clinical practice to any great extent until about 1950. Around 1955 several of these vascular surgical techniques were adopted by Norwegian surgeons, mainly at Rikshospitalet and Ullevål.

In 1934 a saddle embolus was removed from a 74-year-old woman at Haukeland. Embolectomy was performed in the aortic bifurcation as well as both femoral arteries, but the patient died two days later. Without heparin and Fogarty catheters this operation was unlikely to be successful at the time.

Aorto-iliac and Infrainguinal Atherosclerosis
At Ullevål, vascular surgery was introduced by Carl Semb and Frank Bergan. On the 16th of February 1955 they did what probably was the first thrombendarterectomy in Norway. In June the same year, Leif Efskind at Rikshospitalet, used thrombendarterectomy both for femoropopliteal and aorto-iliac atherosclerosis. In November that year thrombendarterectomy was also used at Drammen. At Rikshospitalet freeze-dried homologous arteries were applied for femoropopliteal bypass grafting already in 1956. However, aneurysm formation became a problem and synthetic prostheses were therefore used, at first nylon, which was unsuccessful, and thereafter dacron.

At Ullevål translumbar aortography had been introduced in 1947, but was replaced by the Seldinger technique with arterial punction in the groin in the early 50ies. Thrombendarterectomy became the main method both for the treatment of aorto-iliac and femoropopliteal atherosclerosis during the first years. Already in 1956, 23 thrombendarterectomies of the femoral artery had been performed at Ullevål, and the results of the first 57 operations published in 1958 (1). Bergan and Sverre Vasli compared the results of reversed saphenous vein bypass grafting and endarterectomy in the femoro-popliteal area. This work led to the application of saphenous vein bypass grafting as the standard method for infra-inguinal atherosclerosis at this institution from 1961. From the early 1960ies dacron vascular graft replacement became the method of choice for the treatment of aorto-iliac atherosclerosis.

In 1960 Karl Victor Hall conceived the idea of using the long saphenous vein in-situ as a bypass graft for femoro-
popliteal and femoro-tibial atherosclerosis. The valves were at first removed through separate small incisions (Fig. 1).

His first clinical experience was published in 1962 (2). The method had a renaissance in the 1970ies due to refinement of instruments, meticulous surgical technique and the introduction of a metal valve stripper described by Hall in 1973. The American surgeon Robert Leather reported excellent results with the in-situ technique for distal bypass. This also increased the popularity of the method, which is now accepted as the standard technique in several centres around the world, especially for femorodistal bypass grafting. Hall was also the second to describe the popliteal entrapment syndrome. The first profundaplasty was done at Aker in 1971, after it had been introduced by Peter Martin, at Hammersmith Hospital, London. The first Dardik biograft was also implanted at Aker in 1978, and this method was used until late 80ies. However, aneurysm formation was reported and therefore PTFE and Dacron were used for femoro-popliteal bypass above the knee. A Scandinavian prospective trial indicated that Dacron actually performed better than PTFE in this position. Semiclosed endarterectomy was also used below the inguinal ligament when the saphenous vein was unavailable for bypass. However, the long-term results were not optimal.

The first extra-anatomic bypass in Norway was performed as a femoro-femoral bypass at Ullevål in 1972 and also axillo-femoral bypass was performed early at this hospital. At Haukeland, the first extra-anatomic bypasses were made in 1974 and they published large series of extraanatomic bypass grafting. Carotid-subclavian bypass was performed at Ullevål in 1970, in a patient with subclavian steal syndrome.


Aortic Aneurysms
The first attempt at treating an abdominal aortic aneurysm (AAA) took place at Haukeland, in 1952 using a “Surgaloy Mesh” wrapping. This technique was not used to any great extent in other hospitals. The first elective operation for abdominal aortic aneurysm was performed by Efskind at Rikshospitalet in 1956. A homologous vascular graft was used, and the postoperative course was uneventful. The first operation for ruptured aneurysm was performed at Ullevål by Bergan in 1963. The patient, a 69 year-old man, was in shock and lived only for one day. The first successful operations for ruptured AAA were performed in 1968. This year such operations were performed at three hospitals; at Ullevål by Georg Brabrand, at Aker by Vasli and in Tromso by Johnsson. Since then there has been a significant increase in the number of operations for AAA, similar to what is seen in other western
countries. Operations for aneurysm in peripheral arteries have not been recorded systematically, but the first operation was performed at Ullevål in 1958.

The first results of thoracoabdominal aortic aneurysm repair were reported from Trondheim in 1985. Since then new techniques have been introduced, and most of these procedures are now performed with adjuncts like left heart bypass, sequential clamping of the aorta and selective perfusion of the renal and visceral arteries. Techniques for protection of the spinal cord have also been introduced and the mortality and complication rate is decreasing. From Department of Thoracic and Cardiovascular Surgery, Rikshospitalet, the experience with thoracoabdominal aortic surgery has been reported at national and international conferences.

Carotid Surgery
Pioneering work had been done in the field of carotid and vertebral angiography by Arne Engeset and Tormod Hauge. Engeset presented his experience with carotid angiography in his doctoral thesis as early as in 1944. The first successful carotid endarterectomy in Norway was performed at Ullevål in 1958 by Bergan and Kristian Kriistiansen. Neurosurgeons had been involved in the treatment of cerebrovascular insufficiency from the beginning. However, carotid surgery has later been the domain of vascular surgeons. Most of the carotid operations were performed by the application of a shunt and autologous venous patch. Blood flow was measured routinely after the reconstruction.

Haukeland was the first hospital to introduce endovascular treatment of carotid artery stenosis in 1996 by Jan Wirsching and Svein Amundsen. Although several reports have indicated results of stenting comparable to surgery, conventional endarterectomy is still the dominating treatment modality for carotid artery stenosis in Norway. The number of carotid operations in Norway is about 300–350 per year.

Vascular Trauma
Norway has a relatively low incidence of vascular trauma compared to several other countries, although there has been an increase during recent years. Bergan operated a patient with traumatic aortic rupture by using a Dacron graft already in 1955, which to our knowledge was the first such procedure in Norway. In 1994 a stent-graft was applied to repair an axillary arterial injury in Trondheim.

Early Endovascular Therapy
Already in 1967, Ivar Andresen and Torbjørn Hjeme-dal from Aust-Agder County Hospital, published their experience with seven patients treated with the Dotter angioplasty for infra-inguinal arterial obstruction. However, this method was soon abandoned, and it was not until the introduction of Grünzig’s balloon angioplasty that endovascular treatment became important for the treatment of atherosclerosis. The first balloon angioplasty a.m. Grünzig in Norway was made by Staal Hatlinghus and Ivar Enge at Aker in March 1980, in a female patient with stenosis of the superficial femoral artery. Their first experience was published in 1981 (3). Almost simultaneously the method was also used at Ullevål by the radiologist Ragnar Hol. Aker was at first the leading hospital regarding endovascular treatment, both of aorto-iliac and femoro-popliteal occlusive disease. During 1980 also renal artery stenosis in a patient with renovascular hypertension was treated by balloon angioplasty, and a patient with “claudication” of the left arm was treated by balloon angioplasty of the left subclavian artery. Thus, the first angioplasty for renal artery stenosis (PTRA) was performed in 1980 and the results from Aker and Levanger Hospital, where Hatlinghus now worked, were presented in 1983 at the Scandinavian Radiological Conference in Oslo. In 1982, the technique was also applied at Rikshospitalet, at first on patients with arterial stenosis in transplanted kidneys. Later on they have published a significant experience with this technique in other patient groups.

The first use of thrombolysis was applied already in the late 60ies at Aker. The method had a renaissance in the 1980ies for the treatment of acute arterial obstruction, but the risk of bleedings still make the right selection of patients imperative.

Venous Surgery
The development of blood flowmetry led to important investigations made by Roald Bjordal (1928–2003) in his PhD-thesis where he studied venous hemodynamics in
patients with chronic venous insufficiency. He studied patients with primary varicose veins, as well as patients with deep venous insufficiency, and also investigated the function of the perforators by applying intravenous pressure measurements in addition to blood flowmetry. Bjordal’s work contributed to the understanding of the pathophysiological process and the prognosis following surgical therapy. Later Duplex scanning has become the most important method for investigation of venous disease.

During recent years, radiofrequency therapy and the injection of sclerosing foam have been used instead of conventional stripping of varicose veins. In selected cases of deep venous insufficiency, vein valve reconstruction has become an alternative. As the only hospital in Norway, Aker has introduced this treatment modality, and promising results have been presented. Aker also pioneered within the application of modern thrombolytic treatment of deep venous thrombosis. It seems that better conservation of the venous valves is obtained following thrombolytic treatment compared to conventional heparin treatment only.

**Medical Technology and Vascular Diagnostics**

Electromagnetic flowmetry had been described in 1956 by Spencer and Dennison, but the instrument was not commercially available at the time. In cooperation with Hårek Hognestad, Christian Cappelen and Hall developed an electromagnetic flowmeter at the Norwegian Institute of Industrial Research. This flowmeter gained international reputation as a safe and reliable instrument and was produced by Nycotron, Norway. The most recently developed flowmetry technique is the ultrasound transit time flowmeter. An example is the VeriQ flowmeter developed by Medi-Stim, Norway, comprising a computer-based system with trend functions and ability to measure peripheral vascular resistance.

Significant contributions within the field of biomedical engineering of importance for vascular surgery have also been made in Trondheim. Cooperation between the Medical Faculty and the former Norwegian Institute of Technology by the cardiologist Liv Hølte and Bjørn Angelsen (engineer) led to the development of excellent duplex ultrasound equipment for non-invasive investigation, both of the heart and the peripheral circulation. This equipment is widely used in cardiological and vascular centres all over the world and was first commercialised by Vingmed, Norway, later by General Electric.

When non-invasive vascular diagnostic methods such as plethysmography and Doppler ultrasound units became available in the later 1960ies, the techniques were soon applied at Aker. At first, the examinations were handled by vascular surgeons, and simple tests by a hospital engineer. From mid-seventies the current leader, the physiologist Einar Strand, in parallel with his PhD-thesis, started establishing a separate vascular laboratory for research and clinical studies (8). “Oslo Vascular Centre” was established in 2005. The centre included an angiological outpatient clinic in addition to the outpatient clinic for circulatory physiology.

Duplex ultrasound scanning has become more and more important, especially in the preoperative diagnosis and follow-up of vascular diseases. CT and MR-angiography have replaced conventional angiography for diagnostic purposes. Sometimes more sophisticated methods are necessary, especially for diagnosing rare vascular diseases and microvascular disorders. The Department of Circulatory Physiology at Aker, under the leadership of Strand, has the most complete vascular laboratory in Norway covering most techniques for vascular diagnosis (4). A large part of their technical equipment is developed at the department.

**Organisation of Vascular Surgery**

In 1981, altogether 52 Norwegian hospitals reported that vascular surgery was performed. 39 of which did elective operations. However, only eight centres reported that more than 100 arterial operations were done in 1981. Since the transportation of patients may be relatively cumbersome in Norway, one found it advantageous for the general surgeons to have a certain background in vascular surgery, at least at county hospitals. Vascular surgery has therefore been included in the requirements for becoming a specialist in general surgery.

Similar to other countries in the Western World, the need for vascular surgery had been steadily increasing. In 1969, 1100 arterial operations were performed. The number increased to 2000 in 1976. In 1981, 2500 operations were performed, an average of 600 operations per million inhabitants. In the same year, approximately 1200
operations per million inhabitants were done in Oslo. Venous surgery is excluded from these data. The introduction of new endovascular techniques, as well as the issue of hospital volume and quality, has led many to advocate a centralisation of vascular surgery. Recently one has concluded that there is need for a centralisation of the vascular surgery, especially after the introduction of new endovascular methods.

Vascular surgery was recognised as a subspecialty based in general surgery in 1986. In addition to four years of general surgery, three years of vascular surgery at a recognised training centre is required. Furthermore, 200 specified vascular operations should have been performed and 80 hours of courses are compulsory before specialist recognition is obtained. The Norwegian Society for Vascular Surgery was established in May 1990 and was recognised by the Norwegian Medical Association in 1991. The Norwegian Society for Vascular Surgery has two annual meetings; one at the end of October and then a Winter meeting at the beginning of March. A national vascular journal "Norsk Karkirurgi" is distributed to the members. A textbook "Nordic Vascular Surgery" was published in 1997 with Hans O. Myhre as editor (5).

In a report “Vascular surgery in Norway” from 1993 (6) the need for vascular procedures in Norway, with the exception of venous surgery, was estimated to about 1500 per million inhabitants. In 2002 a report on the structure and organisation of Norwegian vascular surgery in the future (7) was made. It was concluded that since vascular surgical techniques became more complicated, there was a need for centralisation. The plan is to have “centres” with round the clock service including the necessary cooperation with interventional radiologists. According to the Norwegian Medical Association there were in April 1911 154 certified vascular surgeons in Norway, and approximately 91 of them worked in clinical practice.

During the 1990ies and after the year 2000 there has been a steady increase in the number of vascular procedures in Norway according to the national registry, NorKar, which was established in Trondheim in 1995 (Fig.2). NorKar, as other clinical registries in Norway, will probably be reorganised in the near future under the leadership of the Norwegian Directorate of Health. It is the hope that this registry will form the basis for a log-book for trainees in vascular surgery, and that reporting to the registry will be compulsory.

The number of open operations for aorto-iliac disease has decreased significantly and most of these lesions are now treated by balloon angioplasty with or without stenting. Also infrainguinal disease is increasingly being treated with balloon angioplasty, which also has become the primary method for the treatment of renal artery stenosis (8). Early in the 1990ies vascular stents became commercially available. The first stenting procedures in the aorto-iliac segment were performed at Ullevål while stenting of the renal arteries were first performed at Rikshospitalet. Aker reported the first Norwegian experience with laparoscopic aorto-iliac surgery for occlusive disease in 2005.

In 1997, a report on smoking and vascular diseases was made by members of the Norwegian Society for Vascular Surgery. The strong association between smoking and atherosclerosis lead to the conclusion that vascular surgeons should pay more attention to prevention, including smoking cessation programmes in patients with vascular diseases. Especially for patients with intermittent claudication, systematic training programmes should be arranged. In addition, it was realised that these patients did not get proper medical treatment. Oslo Vascular Centre at Aker has organised the care of vascular patients in an excellent manner and a supervised training programme is an important part before elective surgery is planned.

European Society for Vascular Surgery was founded in 1987 and Hans O. Myhre became the first president of the society (9). The society and its journal “European Journal of Vascular and Endovascular Surgery” have had a great impact on European vascular surgery in general, and also on Norwegian vascular surgery. In September 2009, the annual conference of this society had their meeting in Oslo with Jørgen J. Jørgensen, Aker, as chairman of the local organising committee. The Norwegian Society for Vascular Surgery decided that 2009 should be regarded the “year of vascular surgery” with focus on patients with vascular diseases. The “day of vascular surgery” was arranged at hospitals all over Norway on the 27th May 2009 (Fig 4). Demonstration of diagnostic techniques, lectures about various vascular disorders etc. were arranged. In addition, a web portal for vascular surgery in Norway was established (www.karkirurgi.org).
The “Endovascular Era”

Volodos published his first experience with endovascular therapy for aneurysmal disease already in 1986 and Parodi in 1991. Endovascular aneurysm repair was introduced in Norway in 1995 when the first treatment of an abdominal aortic aneurysm was performed on the 3rd of February in Trondheim. Jan Lundbom and Staal Hatlinghus did pioneering work with stent-grafting (Fig 3). They trained colleagues, both in Norway and in other countries in stent-grafting for abdominal aortic aneurysm. This treatment modality is now used at 10 hospitals in Norway. An annual course in endovascular therapy including the use of simulators is arranged in Trondheim as a collaboration between radiologists and surgeons.

The first thoracic stent-grafting was performed in Trondheim in 1997. The first 10 thoracic stent-grafts were so-called homemade, consisting of uncrimped polyester tubes were Gianturco Z-stents had been sutured on the inside. These implants functioned well, but have later been replaced by commercial products. The technique was first used for aneurysmal disease, but the indications have later been extended to complicated type B dissection, pseudoaneurysm, traumatic lesions of the thoracic aorta etc.

Although some of the indications for thoracic aortic stent-grafting are still controversial, the method is regarded the primary choice for traumatic aortic rupture. Stent-grafting for thoracic aortic disease is so far performed at some of the university hospitals only. Hybrid operations for aneurysm and dissection were reported in 1998, while the first stent-grafts with side-branches to treat complicated aorto-iliac disease were used in 2002.

The endovascular era led to closer cooperation between vascular surgeons and interventional radiologists in the treatment of patients with vascular diseases. Thus, combined operations including open surgery as well as endovascular techniques are being more and more common. This cooperation is also reflected in the construction of so-called hybrid operating rooms for vascular surgery. In such operating rooms regular facilities for open surgery combined with an angiography laboratory is permitting both approaches to be applied during the same anaesthesia. The first hybrid operating room was established at the Interventional Centre, Rikshospitalet, and later at Aker in 1999. Another example is the “Operating Room of the Future” at St. Olav’s Hospital in Trondheim (www.stolav.no/for)
Research

About 20 PhD-theses have been delivered at Department of Circulatory Physiology, Aker. The main focus, in addition to clinical research, has been studies of arterial- and venous physiology and patophysiology, transcapillary fluid balance and edema mechanisms, microcirculation, regulation of peripheral circulation and medical technology. A similar number of PhD-theses has been made at the surgical clinic, St. Olav's Hospital, Trondheim, where a close collaboration with the research institution SINTEF has been extremely valuable. Several theses have been made regarding the consequences of cross-clamping of the thoracic aorta and various aspects on thoracoabdominal aortic surgery including protection of the spinal cord. In 1990 Petter Aadahl received the prize for the best contribution at the annual conference of the European Society for Vascular Surgery. At Haukeland, the main research projects have been on long-term patency rate and survival following various vascular diseases. The Tromsø-investigation, which is organised from the University Hospital of Tromsø, has given us valuable information, especially on epidemiology and risk factors of aortic aneurysmal disease and carotid artery disease including plaque morphology. High-quality scientific papers with new and valuable information have been published from the Tromsø-study (10).

References

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31. The Norwegian Society for Vascular Surgery

Hans O. Myhre, Jarlis Wesche and Thomas Nyheim


A provisional Board was elected in 1990. Bjarne Haavik was the first chairman and Andries Kroese, Hans O. Myhre and Henrik Dedichen were members of the founding board.

Table 31-1. The Chairmen of the Society have been:

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<th>Year</th>
<th>Chairman</th>
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<tr>
<td>1990-1991</td>
<td>Bjarne Haavik</td>
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<td>1991-1995</td>
<td>Ola D. Sæther</td>
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<td>1995-1998</td>
<td>Terje Hasselgård</td>
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<td>1998-2000</td>
<td>Torbjørn Dahl</td>
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<td>2000-2002</td>
<td>Erik Halbakken</td>
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<td>2002-2004</td>
<td>Anne Karin Lindahl</td>
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<td>2004-2006</td>
<td>Jarlis Wesche</td>
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<tr>
<td>2006-2008</td>
<td>Gustav Pedersen</td>
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<tr>
<td>2008-2009</td>
<td>Alfred Arvesen</td>
</tr>
<tr>
<td>2010-</td>
<td>Tonje Berglund</td>
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</table>

A year after the foundation of the Society, the journal "Norsk Karkirurgi" was established, with Kroese as the first editor. Initially two or three issues per year were published yearly and delivered to all members, but due to economic constraints the number of issues has decreased.

Training

The Norwegian Society for Vascular Surgery has a permanent committee which works with the education of vascular trainees, and requirements of national certification for specialisation in vascular surgery. This educational committee was established in 1986. The first members were Myhre, Karl Fr. Kordt and Dedichen. At present the elected educational committee consists of the following members: Tor Florenes, Jarlis Wesche, Erik Halbakken, Svein R. Amundsen and Steinar Kiel (as a representative for vascular trainees).

The group organises and ratifies courses, and issues the specific recommendations for open and endovascular procedures required for certification as a specialist in vascular surgery. At present the candidates are required to be specialists in general surgery with at least three years additional training in a recognised department of vascular surgery. 1½ years of this vascular surgical training must be completed in a university hospital. 220 specified open vascular procedures are required by the candidate in addition to 20 endovascular procedures. Finally, a total of 80 hours attending obligatory and optional courses are necessary prior to the specialist recognition. In cooperation with the Norwegian Medical Association an Internet distant education course in circulatory physiology has been established. There is an annual course in vascular surgical techniques where the candidates perform vascular operations on pigs. A simulator based course in endovascular procedures has
also been established. As a consequence of the increasing
trend towards application of endovascular treatment mo-
dalities, the Society plans to increase the current require-
ments of endovascular procedures to 50 over the next two
years. Operating lists and other specialist requirements
can be found at www.legeforeningen.no

Throughout the training period a consultant vascular sur-
geon is appointed as a supervisor for each vascular trainee.
Regular formal meetings are being held to ensure that
the requirements of the specialist training are fulfilled. At
present there are 13 recognised training posts in university
hospitals, where the candidates can complete all 3 years
training, and 6 positions in county hospitals, where 1½
years of vascular training is recognised.

A challenge for NKKF is to stimulate research within
vascular surgery and to encourage establishment of junior
hospital posts with 50% research and 50% clinical work
at the major institutions. Simulators and skills stations
will become increasingly important during the training in
vascular surgery.

The NORKAR Registry
NORKAR was established in 1995 as a national register
in vascular surgery. Annual reports are given at www.
legeforeningen.no/id/12183.0 Data are also delivered to
Vascunet www.esvs.org/?vis=57. Thus, international col-
laboration between vascular registers is well established.
The national registers are about to be reorganised under
the leadership of the Norwegian Directorate of Health.
The aim is that the registry will form the basis for a log-
book for vascular trainees, provide quality control, and
that reporting to the registry will become compulsory.

International Collaboration
NKKF has over the years had extensive international col-
laboration, especially with the European Society for Vas-
cular Surgery (ESVS). The council members are elected by
the members of ESVS in each country. Since the inaugu-
ration in 1987 this society has grown significantly. The
annual meeting in 2009 was arranged in Oslo under the
leadership of Jørgen J. Jørgensen. The meeting was a great
success and about 1500 participants attended the meeting,
including 100 “vascular” nurses and technicians. The ses-
sion for nurses and technicians was arranged for the first
time, and was very successful.

For the past decades the European Union of Medical
Specialists (Union Européenne des Médecins Specialistes
– UEMS) has developed into a comprehensive and rep-
resentative European organisation for medical specialists.
Around 2005 vascular surgery emerged as an independent
mono-specialty in several European countries. Previously
vascular surgery was a sub-section of general surgery. The
European Board of Vascular Surgery Examination is im-
important for harmonisation of vascular training in Europe. This is a voluntary examination, which is arranged during the ESVS annual meeting. Both vascular and endovascular skills are tested at the examination. Norwegian representatives to UEMS Vasc have been Myhre, Anne Karin Lindahl, Flørenes and Kirsten Krogh-Sørensen. Information regarding UEMS may be found on www.uemsvascular.com www.uemsvascular.com/EBVS_New_Logbook.pdf www.uemsvascular.com/EBVS_Application.pdf

During the ESVS meeting in Berlin in 1994 the European Association for Vascular Surgeons in training (EAVST) was founded. In 2008 this society formally became European Vascular Surgeons in Training (EVST) and was incorporated into the European Society of Vascular Surgery. The new society continues to promote issues pertaining to training in vascular surgery in Europe.

Closing Remarks
In Norway the population is scattered over a large geographical area. This continues to challenge our health care system, especially the issue of maintaining a high quality health service even in peripheral hospitals. As transportation has become more effective, a demand for centralisation of vascular surgical units has been forwarded by NKKF. This is a continuous process, which is still under debate.

More information about vascular surgery in Norway is available at www.karkirurgi.org.

Literature

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