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RESEARCH

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Superior long-term patency of no-touch vein graft compared to conventional vein grafts in over 1500 consecutive patients

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Abstract

Objectives To evaluate the long-term angiographic patency of saphenous vein grafts (SVG) harvested using the no-touch technique compared to the conventional technique.

Methods This was a single-center, retrospective, cohort study. The inclusion criteria were individuals who underwent a CABG (coronary artery bypass grafting) between January 1995 and July 2020, and who successively needed a clinically-driven angiography. The primary endpoint was long-term patency. The secondary endpoints were differences in patency based on sub-group analysis (single vs. sequential graft, divided by target vessel).

Results The study included 1520 individuals (618 no-touch, 825 conventional and 77 arterial grafts). The mean clinical follow-up time was 8.4 years ± 5.5 years. The patency per patient was 70.7% in the no-touch grafts vs. 46.7% in the conventional grafts ($p < 0.001$, OR = 2.8). The graft patency was 75.9% in the no-touch grafts vs. 62.8% in the conventional grafts ($p < 0.001$, OR = 1.8).

Conclusions The no-touch vein grafts were associated with statistically significantly higher patency at long-term compared to the conventional grafts.

Clinical trial registration NCT04656366, 7 December 2020.

Clinical perspective

What is new?

•The largest follow-up of the patency of no-touch vein grafts in the international literature.

•Patients with a no-touch vein graft had significantly better patency ($p < 0.001$) at mean follow-up of more than 8 years.

What are the clinical implications?

•Consequent reduction in cardiovascular events after no-touch vein graft.

•Benefits at individual level due to fewer episodes of re-angina and myocardial infarction, and fewer coronary interventions.

•Benefits at community level due to fewer re-hospitalizations and a reduction in healthcare costs.

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Keywords coronary artery bypass graft, major adverse cardiac events, no-touch, patency, saphenous vein, stent

Introduction

Ischemic heart disease is the leading cause of death worldwide, accounting for almost 8.9 million deaths in 2019 [1]. The main treatment options are percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG) and, in some cases, both. The choice of treatment depends on the clinical presentation, grade of disease, type of lesion, and patient comorbidities. Guidelines [2–4] recommend CABG in cases of multivessel disease or left main stem, and/or diabetes mellitus, to improve survival and reduce the risk of major adverse cardiac events (MACE) [5–9], which are defined as death, myocardial infarction (MI), in-stent restenosis, and/or repeated target vessel revascularization (TVR). The grafts used, especially vein grafts, are subject to remodelling and progressive intimal hyperplasia and atherosclerosis, which may lead to graft stenosis or occlusion and thereby limit the graft patency [7]. These events occur more frequently and rapidly in saphenous vein grafts (SVGs) compared to left internal thoracic artery (LITA) or other arterial grafts [8, 9]. Graft patency after CABG is a major determinant of clinical prognosis and long-term survival [7].

The no-touch (NT) technique [10] differs from the conventional technique in that it is associated with less endothelium damage during the harvesting procedure [11, 12] and leads to reduced neo-intimal hyperplasia and subsequent atherosclerosis in the long term [13, 14].

The aim of this study was to evaluate the long-term angiographic patency of saphenous vein grafts (SVG) harvested using the NT technique compared to the conventional technique.

This is a single-center, retrospective, cohort study. The study complied with the STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) statement and the STROBE checklist was used [15].

Materials and methods

Data collection

This single-center study included all individuals treated with a CABG between January 1, 1995 and June 30, 2020 at our Cardiothoracic Department and who successively needed a clinically driven-angiography. The study was a single-center study involving a center with long experience with the NT technique having used it for harvesting the saphenous vein since 1990. No exclusion criteria were defined. The study was performed in accordance with the Declaration of Helsinki. The Regional Ethical Review Board approved the study (Dnr 2020/04168).

The standard operation in our center has been to anastomise the LITA to the LAD (left anterior descending) and vein grafts to the other target vessels; in some cases, total arterial revascularization (A) occurred. The SVG was harvested either with the NT or with the C technique [16]. We used a totally open technique for both the harvesting methods, no bridge techniques or endoscopic techniques were used. The NT grafts were harvested with a 2–5 mm wide fat pedicle. The grafts were not distended with saline solution. The anastomosis leak test was performed with cardioplegia and with the actuarial extracorporeal circulation pressure; no manual or external pressure was used. The C grafts were harvested by stripping them from their surrounding tissues. They were then dilated with saline solution to overcome the spasm due to the harvesting. The anastomosis leak test was performed using saline solution or cardioplegia, usually with manual pressure. As routine the vein graft harvesting begun at the calf, for both the techniques.

The type of technique used was chosen by the surgeon at the time of operation based on individual assessment and, therefore, without randomization. The angiographies were performed in two cardiology departments and were clinically driven, being due to either angina or myocardial infarction. No planned angiographic follow-up was performed. No exclusion criterion was defined.

The grade of stenosis and its significance was defined according to the 2021 American Heart Association for coronary artery revascularization [17]. A limit of 70% was set for the non-left main stenosis and 50% for the left main stenosis or for graft stenosis; in case of doubt, the severity of the lesion was confirmed using the FFR (fractional flow reserve) or the iFR (instantaneous wave-free ratio).

The operative data (CABG) and the procedural data were collected with the help of an intervention-related quality register (the Swedish cardiological and cardiosurgical intervention register Swedeheart) [18]. The operative data regarding the type of vein graft, the number of anastomoses, and the target vessel for the peripheral anastomosis were extracted and double checked by reviewing records in the clinical software of the two hospitals involved.

Statistical methods

The primary endpoint was defined as long-term patency.

Secondary outcomes were the differences between single grafts and sequential grafts, and the different territories fed by the stenosed vein graft based on sub-group analyses.

Descriptive statistics were calculated as means ± standard deviations (SD) for normally distributed variables, as median with interquartile range (IQR) for non-normally distributed variables, and as count with percentage for categorical variables.

The Chi-squared test (or Fisher's exact test for an expected count lower than 5) was used to compare categorical proportions between the two groups (NT and C). The unpaired t-test was performed to compare continuous variables and the Mann-Whitney U-test was used in cases of non-normally distributed data.

The patency rate was calculated both per patient, and per graft. It was not possible to calculate per anastomosis, due to the register characteristics.

Statistical analyses were performed using SPSS version 27.0 (IBM, Armonk, NY, USA).

Results

Between January 2006 and July 2020, 1571 individuals who had previously been treated with CABG needed an angiography (Fig. 1). Fifty-one (3.2%) were lost at

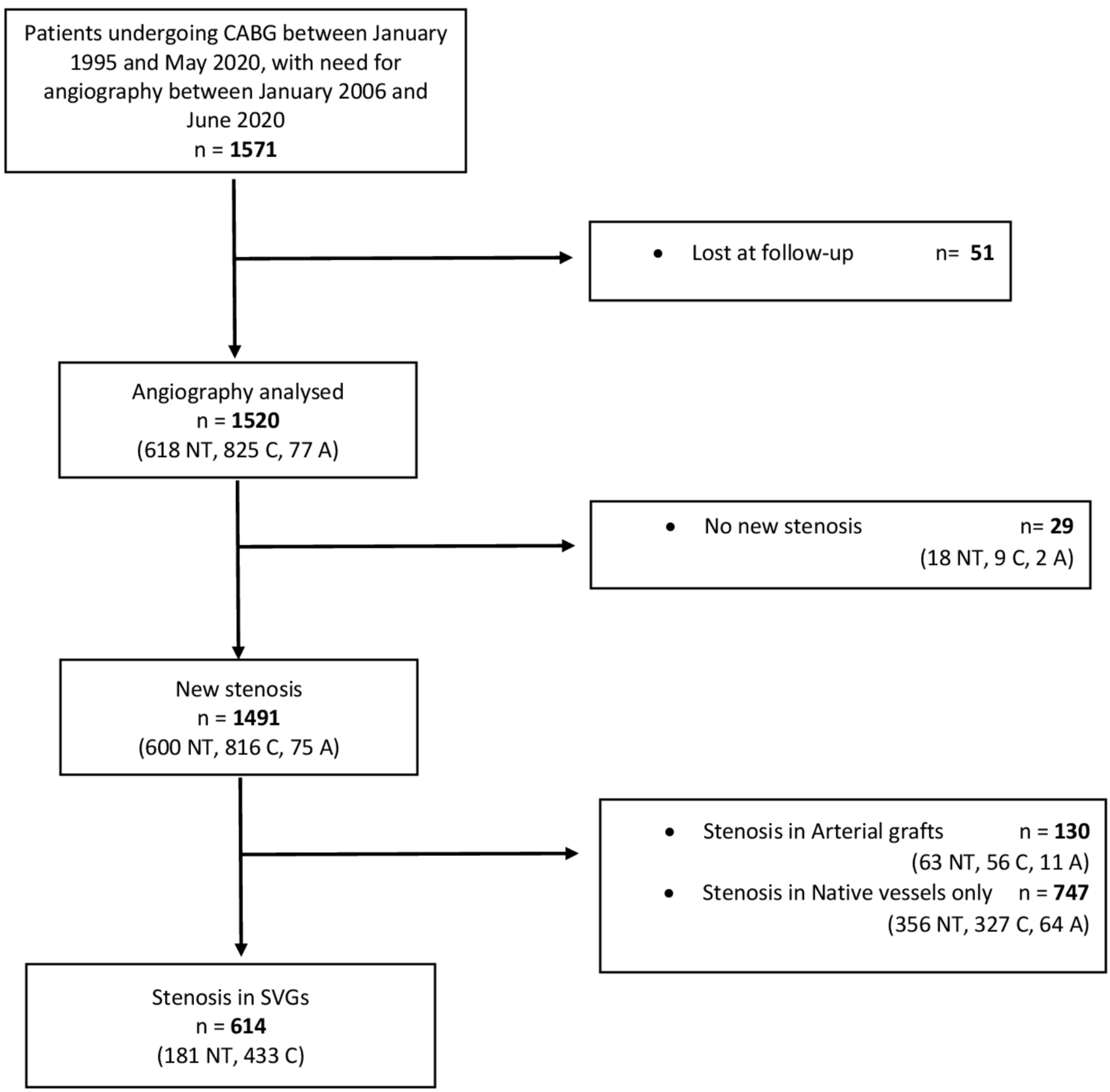

Fig. 1 STROBE flowchart of the individuals included in the study
A: arterial graft alone; C: conventional graft; CABG: coronary artery bypass grafting; NT: no-touch graft; PCI: percutaneous coronary intervention; SVG: saphenous vein graft

Table 1 Graft characteristics of the patients in the total population

Patient characteristics	N (%)
No-touch	618 (40.7)
Conventional	825 (54.3)
LITA to LAD	1273 (83.8)
RITA or Radial	144 (9.5)
Total Arterial	77 (5.1)
No-touch single grafts	203 (13.4)
No-touch sequential grafts	415 (27.3)
Conventional single grafts	450 (29.6)
Conventional sequential grafts	375 (24.7)

Table 2 Vein graft characteristics of the two groups

Patient characteristics	No-touch	Conventional
No. total grafts	908	1656
No. single grafts	463	1247
No. sequential grafts	445	409

Table 3 Demographic characteristics of the individuals who received a saphenous vein graft

Patient characteristics	No-touch	Conventional	p-value
No. of patients, n (%)	618 (40.7)	825 (54.3)	
Mean age at CABG, years ± SD	63.2 ± 8.6	63.1 ± 21.1	0.893
Male, n (%)	506 (81.9)	626 (75.9)	0.006
Hypertension, n (%)	550 (89.0)	687 (83.3)	< 0.001
Hypercholesterolemia, n (%)	567 (91.7)	693 (84.0)	< 0.001
Diabetes mellitus, n (%)	216 (39.8)	284 (34.4)	0.895
Smoking, n (%)	349 (56.5)	440 (53.3)	0.359
Double platelet inhibitor therapy, n (%)	219 (35.4)	363 (44.0)	0.001
Creatinine median (Q1, Q3)	85 (72, 102)	88 (75, 105)	0.004*
Dead at follow-up, n (%)	170 (27.5)	420 (50.9)	< 0.001

* Mann-Whitney U test was used. T-test was used for continuous variables and Chi-squared test for categorical variables. Values are presented as mean ± standard deviation for normal distributed variables, median (Q1, Q3) for non-normal distributed variables, or n (%). Ages and times are given in years. Creatinine is given in micromole/L

follow-up due to the inability to access the surgical reports (i.e., microfilm not available, journal lost, data protection); therefore, they were excluded from the analyses.

The study included 1520 consecutive patients (618 NT, 825 C, 77 A) who needed a postoperative angiography (see Fig. 1; Table 1) with a mean follow-up time of 8.4±5.5 years and up to 24.7 years. The study analysed 2564 venous grafts (908 NT, 1656 C), Table 2.

In 29 cases, the angiography was only diagnostic and no new stenosis was detected. In 614 cases, stenoses were present in at least one vein graft. One hundred and thirty individuals presented with a stenosis in an arterial graft,

Table 4 Operative and procedural characteristics of the individuals who received a saphenous vein graft

Patient characteristics	No-touch	Conventional	p-value
No. of patients	618	825	
No. of grafts	908	1656	
No. of peripheral anastomosis/patient mean ± SD	3.5 ± 1.1	3.5 ± 1.0	0.373
EF % median (Q1, Q3)	60 (50, 60)	60 (50, 65)	< 0.001*
Indication for Angiography n, (%)			0.916
Re-angina	501 (81.1)	667 (80.8)	
MI	117 (18.9)	158 (19.2)	

* Mann-Whitney U test was used. Values are presented as mean ± standard deviation for normal distributed variables, median (Q1, Q3) for non-normal distributed variables, or n (%). EF: ejection fraction. MI: myocardial infarction

and in 747 cases the new stenosis affected only the native vessels.

Demographic, operative, and procedural characteristics

A total of 1443 individuals received an SVG at surgery (618 NT, 825 C). The demographic, operative and angiographic characteristics of this group are summarized in Table 3. The demographic characteristics of the two groups were similar and patients had a comparable age at the time of CABG (63.2±8.6 years NT, 63.1±21.1 years C; $p=0.893$; Table 3); most of the patients were male (78.5%). The risk factor distribution showed a significantly higher rate of hypertension (89% NT vs. 83.3% C) and hypercholesterolemia (91.7% NT vs. 84% C) in the NT group ($p<0.001$). Fewer patients with an NT SVG received a post-operative DAPT (dual anti platelet therapy), 35.4% NT vs. 44% C ($p=0.001$).

The operative characteristics regarding number of peripheral anastomoses were similar in the two groups (Table 4). No differences regarding the indication for the new angiography were presented ($p=0.916$), Table 4.

The mean follow-up time was 5.5±4.4 years for the individuals with an NT SVG and 10.7±5.1 years for the individuals with a C SVG.

Clinical follow-up

Primary endpoint

The total patency rate per patient was 70.7% (437/618) in the NT group and 46.7% (385/825) in the C group ($p<0.001$), with an OR (odds ratio) of 2.8, Table 5.

The patency rate per graft was 75.9% (609/908) in the NT group and 63.5% (1051/1656) in the C group ($p<0.001$), with an OR of 1.8, Table 6.

Secondary endpoint

Single grafts vs. sequential grafts

In the analysis of the different types of graft received (single or sequential), there was a statistically significant higher patency in the NT group both for single grafts

Table 5 Patency rate per patient of no-touch and conventional vein grafts, and patency of arterial grafts divided by type of vein graft

Patient characteristics	No-touch	Conventional	*p*-value
No. of patients	618	825	
Patency/patient Vein Grafts, %	70.7	46.7	< 0.001
Patency/patient Arterial grafts, %	86.4	86.3	0.954
Patency/patient LITA, %	98.4	95.9	0.006

Values are presented as %. LITA: left internal thoracic artery

Table 6 Patency in no-touch and conventional vein grafts divided by type of graft

Grafts characteristics	No-touch	Conventional	*p*-value
No. of Grafts	908	1656	
Graft Patency	75.9	63.5	< 0.001
Single	75.6	62.8	< 0.001
Sequential	76.0	65.3	< 0.001

Values are presented as %

Table 7 Patency of no-touch and conventional vein grafts divided by territory of distribution and sub-divided by graft type (single or sequential)

Grafts characteristics	No-touch	Conventional	*p*-value
To LAD	58/70 (82.9)	45/66 (68.2)	0.046
Single	30/36 (83.3)	35/49 (71.4)	0.201
Sequential	28/34 (82.4)	10/17 (58.8)	0.093*
To DA	317/360 (88.1)	353/519 (68.0)	< 0.001
Single	44/54 (81.5)	160/273 (58.6)	0.002
Sequential	273/306 (89.2)	193/246 (78.5)	< 0.001
To MA	402/468 (85.9)	529/673 (78.6)	0.002
Single	90/104 (86.5)	270/339 (79.6)	0.115
Sequential	312/364 (85.7)	259/334 (77.5)	0.005
To RCA	285/404 (70.5)	355/623 (57.0)	< 0.001
Single	183/256 (71.5)	307/549 (55.9)	< 0.001
Sequential	102/148 (68.9)	48/74 (64.9)	0.543

Values are presented as n, (%). LAD: left anterior descending, DA: diagonal artery,

MA: marginal artery, RCA: right coronary artery. * Fisher's exact test

(75.6% NT vs. 62.8% C, $p<0.001$) and for sequential grafts (76.0% NT vs. 65.3% C, $p<0.001$), Table 6.

Territories fed by the stenosed vein graft

The subgroup analysis, divided by distal anastomosis, revealed statistically significantly better results for the NT grafts for each of the different distribution territories, Table 7. The patency of the NT SVGs was over 80% if the target vessel was a coronary of the left system, and around 70% if the target vessel was the right coronary artery (RCA). In contrast, the patency of the C SVGs was as low as 57% if the target vessel was the RCA, and never reached 80% in the left system. The differences between the NT and the C in the four different territories of distribution were significant even when analysing the single and the sequential grafts separately; however, the exceptions were the single grafts to the marginal artery (MA), the sequential ones to RCA, and both types to the left anterior descending (LAD) due to the limited number of included individuals, Table 7.

Patency of arterial grafts

The long-term patency of the total arterial grafts was 86.3% and of the LITA grafts 96.2%. The patency rates for arterial grafts were similar regardless of whether the patients received an SVG or not, Table 5.

Discussion

This study presents the results from the largest long-term follow-up investigation of the patency of NT SVGs.

The main finding of this study was higher graft patency at follow-up of the NT grafts (75.9%), compared to the C grafts (63.5%); $p<0.001$. The superiority of the NT SVG was shown even when the different types of grafts (single vs. sequential) and the different types of territory of distribution were analysed. It has to be mentioned that NT grafts have shorter follow-up compared to the C grafts; however, this is due to higher rates of restenosis in the native vessels and not in the SVGs themselves.

It is known that C SVGs have high risks of thrombosis, intimal hyperplasia, and early atherosclerosis, which all lead to graft occlusion rates of up to 50–60% after 10 years, according to most clinical records [19–21].

Our study showed similar results for the C grafts with a patency per patient of only 46.7% at a mean follow-up of 8.4 years. The NT grafts, on the other hand, present a patency per patient of more than 70% at follow-up (OR of 2.8) and of almost 76% per graft.

Several studies [11, 13, 14, 16, 22–25] have shown the superiority of NT SVGs compared to C SVGs on follow-up at a mean time up to 16 years [14]. Previous studies have, however, had either a limited follow-up time of maximum 1 year [22, 23, 25] or included a limited number of patients (fewer than 300) [11, 13, 14, 16, 23, 24]. The present study is the first to include both a large cohort, more than 1500 individuals, and a mean follow-up time of more than 5 years and up to almost 25 years. The higher long-term patency of NT SVGs may play an important role in reduced long-term MACE and re-hospitalization rates.

In our previous study [26] we noted a very limited number of patients with NT SVGs being treated with PCI compared to C (63 NT vs. 246 C). We also noted that almost 70% of patients who needed a coronary angiography after the CABG operation did not receive a PCI on their vein graft. The present study gives an explanation for these observations; more than half (57.6%) of the patients with an NT SVG who needed a postoperative angiography did not have a SVG stenosis, but presented with a new stenosis in the native vessels. This occurred in only 39.6% of patients with a C SVG.

Another interesting data is the higher percentage of sequential grafts in the NT group (49.3% vs. 24.7%). This is possible thanks to the qualities of the NT grafts that are much less prone to kinking when performing multiple anastomoses [12], comparing the C technique.

As previously mentioned, NT grafts have a shorter time to follow-up compared to C grafts, with only 23 cases (vs. 124) needing an angiography more than 15 years after the operation. This shorter follow-up time for NT grafts is due to a lower patency rate of native vessels in these individuals. A possible explanation is the statistically significant difference (35.4% vs. 44.0%, $p=0.001$) in the use of DAPT, with NT grafts receiving postoperative DAPT in fewer cases compared to C grafts. The benefits of DAPT after an acute coronary syndrome, in terms of reduced risk of restenosis and higher short- and long-term patency rates, are well known and supported by the international guidelines [27]. Another possible explanation is that in the 1990's, the C graft was used in most cases so these patients automatically have a longer follow-up time than the NT grafts.

The main limitation of this study is that it is non-randomized and the choice of graft type was dependent on the surgeon's choice, and that it is a single-center study. Another limitation is the different follow-up times in the two groups.

Conclusions

The results regarding the NT SVGs are encouraging, with statistically significantly higher patency at long-term follow-up compared to a C SVG, and with an almost 50% reduction in cases of vein graft stenosis long-term.

The results suggest an important reduction of cardiovascular events if the patients receive comparable medical treatment post-surgery and if the management of the risk factors follows the guidelines.

Randomized studies are needed to evaluate the performance and benefits of NT SVGs at both individual (better patency and fewer coronary interventions) and community (fewer re-hospitalizations) levels.

Abbreviations

A	Arterial graft
BMS	Bare metal stent
C	Conventional
CABG	Coronary artery bypass grafting
DA	Diagonal artery
DAPT	Double antiplatelet therapy
DES	Drug-eluting stent
EF	Ejection fraction
FFR	Fractional flow reserve
iFR	Instantaneous wave-free ratio
IQR	Interquartile range
LAD	Left anterior descending artery
LITA	Left internal thoracic artery
MA	Marginal artery
MACE	Major adverse cardiac events
MI	Myocardial infarction
NT	No-touch
OR	Odds ratio
PCI	Percutaneous coronary intervention
RCA	Right coronary artery
RITA	Right internal thoracic artery
SD	Standard deviation
SVG	Saphenous vein graft
TIMI	Thrombolysis in myocardial infarction
TVR	Target vessel revascularization

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13019-024-03057-3.

Supplementary Material 1

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Author contributions

G.F., H.G., N.S., D.S., R.C. and L.B. devised the original concept of this study. G.F., H.G., N.S., D.S., R.C. and L.B. designed the study. G.F., R.L. and A.A. collected the patient data. G.F., R.L. and A.A. performed the statistical analysis. Y.C. provided support for statistical analysis and result explanation. G.F., and Y.C. wrote the first draft of the manuscript. All authors reviewed the manuscript, contributed significantly to its critical review, and approved the final version.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This work was approved by the Regional Ethics Review Board in Uppsala (ref: 2020/04168). The consent to participate was not necessity since it was a retrospective study. The animosity of each individual was grated using a numerical identification code.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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