



Optilene, a new non-absorbable monofilament is safe and effective for CABG anastomosis. OPTICABG - A prospective international, multi-centric, cohort study

Adrian Ursulescu^a, Petra Baumann^{b,*}, Manel Tauron Ferrer^c, Monica Contino^d,
Claudia Romagnoni^d, Carlo Antona^d, Josep Maria Padró Fernández^c

^a Robert Bosch Krankenhaus, Department of Cardiac and Vascular Surgery, Auerbachstrasse 110, 70376, Stuttgart, Germany

^b Aesculap AG, Medical Scientific Affairs, Am Aesculap Platz, 78532, Tuttlingen, Germany

^c Hospital de La Santa Creu I Sant Pau, Department of Cardiac and Vascular, Surgery, Carrer de Sant Quinti 89, 08026, Barcelona, Spain

^d Ospedale Luigi Sacco, Department of Cardiac and Vascular Surgery, Via G B. Grassi 74, Milano, 20157, Italy

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ABSTRACT

Introduction: Coronary artery bypass grafting (CABG) is performed to improve quality of life and to reduce cardiac-related mortality and morbidity in patients with coronary artery disease (CAD). The aim of the present observational study was to assess the performance of a new suture material (Optilene) for anastomosis construction in CABG surgery using a routine clinical procedure. Performance was assessed using the incidence of major adverse cardiac and cerebrovascular events (MACCE).

Methods: The study was designed as an international, multi-centre, prospective cohort study to evaluate the safety and efficacy of a new non-absorbable monofilament for CABG surgery compared to data published in a previous meta-analysis. Optilene suture was used to create the distal and proximal coronary artery anastomoses. The primary endpoint was the cumulative MACCE rate up to discharge. Secondary parameters were intraoperative handling of the suture material and QoL up to 3 months after surgery. Patients were examined 30 days and 3 months postoperatively.

Results: In total, 199 patients were enrolled in 3 centres in Europe. The cumulative CABG adverse event rate up to the day of discharge was 3%, in contrast to the 8.46% given by the data generated by Nalysnyk et al. A *t*-test showed that our CABG rate was significantly lower. QoL significantly increased from preoperatively until 3 months after surgery. Ease of handling the suture material was rated as very good.

Conclusion: Optilene suture material represents a safe and effective alternative to existing sutures used in CABG surgery for anastomosis construction.

1. Introduction

Coronary artery bypass graft (CABG) surgery is one of the most frequently performed elective surgical procedures [1]. CABG is a safe concept and is routinely conducted in patients with coronary artery disease (CAD) to improve quality of life and to reduce cardiac-related mortality. CAD is the foremost leading cause of mortality in the Western world and is the most common cause of heart failure. CABG was introduced in the 1960s. Since then CABG surgery has become the most studied intervention in the history of surgery. It is highly effective in the treatment of severe angina and delays unfavourable events such as death, myocardial infarction and recurrence of angina. The randomized clinical SYNTAX trial performed in the US and Europe has investigated

CABG surgery versus percutaneous coronary interventions (PCI) in patients with left main coronary disease or three vessel disease [2]. Based on a 5 year follow-up the authors concluded that CABG surgery should be the standard of care for patients with complex lesions (high SYNTAX score (≥ 33) or intermediate (22–32) SYNTAX score). However for patients suffering from a less complex disease (e.g. left main disease with low SYNTAX score 0–22 or intermediate 23–32 SYNTAX Score or three-vessel disease with low SYNTAX Score 0–22), PCI is an acceptable alternative to CABG [3].

The most frequently reported complications after CABG are myocardial infarction (MI), stroke, death, graft stenosis and renal failure. Thus, myocardial infarction, stroke, death, and repeat revascularisation are defined as major adverse cardiac and cerebrovascular events

* Corresponding author.

E-mail address: petra.baumann@aesculap.de (P. Baumann).

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(MACCE). The recently published SYNTAX trial comparing CABG surgery versus PCI in 1800 patients with multi-vessel disease or left main disease reported the following 5 years complication rates for CABG: myocardial infarction (3.8%), death (11.4%), stroke (3.7%), revascularisation (13.7%), MACCE (26.9%) vs. PCI: myocardial infarction (9.7%), death (13.9%), stroke (2.4%), revascularisation (25.9%), MACCE (37.3%) [3].

In general, CABG operations are performed either on-pump or off-pump. Several randomized controlled studies have been conducted showing that “off-pump CABG” is as safe as on-pump surgery. Three large studies (CORONARY trial, ROOBY trial, GOPCABE trial) have intensively investigate the clinical outcome of off-pump versus on-pump CABG surgery [4–9]. Lamy et al. reported no significant difference in the CORONARY trial involving 4752 patients, regarding the composite primary outcome of death, stroke, myocardial infarction, and renal failure at 30 days and 1 year after surgery in patients undergoing off-pump versus on-pump CABG surgery [4,5]. But a trend toward more repeat revascularisation was associated with the off-pump CABG (1.4% vs. 0.8%). Therefore, a long-term follow-up of 5 years has been performed in the CORONARY study, supporting the previous data for the composite outcome of death, stroke, myocardial infarction and renal failure. Revascularisation rate after 5 years was 2.8% in the off-pump group and 2.3% in the on-pump group, ($p = 0.29$) indicating no significant difference [6]. Further secondary endpoints of the CORONARY study were economics and the Quality of life [6]. The 5 years result showed a similar outcome regarding Quality of life for both techniques. Also the costs per patient did not differ between the procedures. Authors of the CORONARY trial concluded that both procedures are equally effective and safe [6].

The ROOBY trial which enrolled a total of 2203 patients showed no significant difference between off-pump and on-pump CABG regarding the composite primary endpoint (death or complications) at 30 days postoperatively. In contrast, the 1 year and 5 year composite outcome rate (death, repeat revascularisation, myocardial infarction) was higher for the off-pump than for the on-pump CABG group (9.9% vs. 7.4%; $p = 0.04$ and 31.0% vs. 27.1%; $p = 0.046$) respectively [7,8]. In addition, the 5 year survival rate was higher in the on-pump CABG group. The ROOBY Investigators concluded that their 5 year results support the findings of a Cochrane Systematic Review from 2012 that off-pump CABG does not generally offer any substantial advantages over on-pump CABG, except possibly in unusual situations such as for example, in patients with an extensively calcified aorta, in which the off-pump technique may result in less manipulation of the aorta, potentially decreasing the risk of aorta emboli or stroke [8].

The German GOPCABE trial randomly allocated 2539 elderly patients (≥ 75 years) either to on-pump or off-pump CABG surgery [9]. Primary combined endpoint was death, stroke, myocardial infarction, repeat revascularization or new renal displacement therapy at 30 days and 1 year after surgery. No significant difference was observed within 30 days after surgery between both treatment groups in regard to the composite endpoint (7.8% off-pump vs. 8.2% on-pump; $p = 0.74$) or to the individual components except for repeat revascularisation which occurred more frequently in the off-pump group (1.3% vs. 0.4%, $p = 0.04$). At 12 months postoperatively the clinical outcome of the off-pump group was similar to the on-pump showing no difference in the composite endpoint (13.1% vs. 14.0%; $p = 0.48$) as well as in the individual components. Authors sum up that their findings do not support the assumption that off-pump CABG can improve the early outcome in high-risk patients. This is consistent with other scientific statements, which conclude that both treatments may lead to an excellent clinical result and that other factors, are more likely to influence the outcome than the choice of the procedure [9].

The results of the meta-analysis published by Nalysnyk et al. served as a basis for the conception of this observational study [10]. The meta-analysis included subgroup analyses which were important for the design of the current observational study. Nalysnyk et al. [10] analysed

the in-hospital adverse events such as MI, stroke, death, gastrointestinal bleeding (GI), renal failure, mortality and the 30-day mortality rate in the following subgroups: studies performed in Europe, elective CABG, cohort studies, multi-centric studies, and patients without a prior CABG. The outcomes of these subgroup analyses were pooled and gave the following complication rates for myocardial infarction (2.82%), stroke (1.93%), GI bleeding (1.28%), renal failure requiring dialysis (0.7%), mortality (1.72%) and 30-day mortality (2.1%), leading to a cumulative MACCE rate of 8.46%, which served as the reference in the present study.

The aim of the OPTICABG study was to assess the performance of a new suture material (Optilene® B. Braun Surgical SA, Rubi, Spain) in elective primary coronary artery bypass graft surgery performed using routine clinical procedures in patients undergoing either on-pump or off-pump surgery. The Optilene® suture consists of 95% polypropylene and 5% polyethylene and, therefore, offers increased flexibility and better handling compared to a pure polypropylene suture material. Safety and efficacy parameters commonly used in CABG surgery were employed to evaluate the performance of the suture material. Safety outcome was compared to the cumulative MACCE rate of 8.46% (reference). If the results from the present study are equal to or better than this reference, the suture material Optilene® can be regarded as a safe and effective alternative suture for CABG surgery.

2. Methods

The OPTICABG study is reported in accordance with the STROCSS Guideline [11] which became a standard for the publication of cohort studies in 2017.

2.1. Registration and ethics approval

In accordance with the Declaration of Helsinki, this cohort study was registered with www.clinicaltrials.gov under the registration number [NCT02546557]. The final study protocol has been approved by the Ethics Committees responsible for the participating clinics (Ethics Committee, University Tübingen; Comité Ético de Investigación Clínica, Hospital de la Santa Creu i Sant Pau; Ospedale Luigi Sacco, Comitato Etico Interaziendale Milano Area A). Ethics approval was needed to meet national requirements. A clinical study protocol was developed a priori but not published in a peer-reviewed journal.

2.2. Study design

The study was designed as an international, multi-centre, prospective, observational, single-arm cohort study. Enrolment took place between November 2015 and February 2017 in three community hospitals located in Germany (Robert Bosch Krankenhaus, Stuttgart), Spain (Hospital de la Santa Creu i Sant Pau, Barcelona) and Italy (Ospedale Luigi Sacco, Milano). Last patient out was in May 2017. Patients were examined on the day of discharge, and on 30 days and 3 months after surgery. Data collection and clarification were completed in July 2017. Analysis was performed in August 2017 and a final clinical study report was completed in November 2017.

2.3. Population and intervention

Each centre included between 50 and 75 patients undergoing elective coronary artery bypass surgery for revascularisation. Patients were treated in accordance with the local clinic standard; the distal and proximal anastomoses were sutured using Optilene® suture material manufactured by B. Braun Surgical SA, Rubi, Spain.

The suture material was applied by senior physicians, consultants and residents who had been trained in, and were familiar with, the use of the suture material. The participating surgeons selected the size of the USP thread used. No control group was included. Subgroup analyses

have not been performed.

2.4. Inclusion and exclusion criteria

Patients older than 25 years, scheduled for elective primary coronary artery bypass graft surgery for the repair of a multi-vessel disease or left main coronary disease using either on-pump or off-pump surgery were eligible for this cohort study. All enrolled patients gave their written informed consent to the scientific analysis of their pseudonymized data set in accordance with the Data Protection Law.

Exclusion criteria:

- Emergency surgery
- Insulin-dependent diabetes mellitus
- Acute myocardial infarction with CK-MB level > 10% of CK and/or ECG signs
- Known immunodeficiency or immunosuppression
- Other combined aortic valve intervention except cardiac valve or mitral valve surgery
- Participation or planned participation in another cardiovascular study before study follow-up is completed
- Inability to give informed consent due to a mental disorder, learning disability, or language barrier.

2.5. Recruitment and follow-up

Patients were recruited from the patient population treated at the participating hospitals as part of daily clinical routine according to the clinic's standard. No additional follow-up visits were performed for this cohort study. Patients completed the study 3 months after surgery. Regular monitoring visits were performed at all hospitals to ensure the quality and validity of the data.

2.6. Sample size calculation

No sample size calculation was performed. A sample size of 200 patients was selected based on the number of patients that can be recruited to a multi-centre, observational study within the reasonable recruitment period of one year. This was considered adequate to detect substantial deviations in efficacy or safety compared to reference [9]. To avoid centre-specific effects, a maximum of 100 patients could be enrolled by one centre. The outcome of the current study was compared to the results of a meta-analysis published by Nalysnyk et al., in 2003, which provided post-CABG adverse event incidence and mortality rates.

According to the data of Nalysnyk et al. the cumulative incidence of adverse events was calculated to be:

- Myocardial infarction (2.82%)
- Stroke (1.93%)
- GI bleeding (1.28%)
- Renal failure (0.70%)
- Mortality (1.72%)

The following subgroups were used for calculations by Nalysnyk et al.:

- European population
- Elective CABG
- Cohort studies
- Multi-centric
- No prior CABG

The median group rates were used to compute the weighted mean for each adverse event category as given above. A cumulative incidence of 8.46% was obtained for the adverse events in question. In regard to this value, the current study had a power of 83.9% to detect a 75%

increase in the cumulative risk. If the data from the current observational study did not differ significantly from the published data, the suture material Optilene® could be regarded as safe and effective for CABG surgery.

2.7. Statistical methods

All statistical tests were performed two-tailed with the pre-specified significance level of $\alpha = 5\%$. A confirmatory statistical test was performed for the primary endpoint; exploratory statistical tests were performed if appropriate for evaluation of effects of interest. Analysis was performed using SAS 9.4 software (SAS Inc., Cary, NC).

2.8. Outcomes

Primary variable was the incidence of early in-hospital CABG adverse events occurring up to the day of discharge. In-hospital CABG adverse events were myocardial infarction, stroke, death, GI bleeding and renal failure.

2.8.1. Secondary variables were divided into safety and efficacy parameters

Safety parameters:

- Incidence of the individual components of in-hospital CABG adverse events up to day of discharge (death, stroke, MI, renal failure, GI bleeding)
- Incidence of stroke, MI up to 30 days \pm 10 days and 3 months \pm 2 weeks postoperatively
- Incidence of the 30-day \pm 10 days and 3-month \pm 2 weeks mortality rates
- Anastomosis revision due to anastomotic bleeding or other causes

Efficacy parameters:

- Frequency of repeat revascularisation leading to CABG or PIC 30 days \pm 10 days and 3 months \pm 2 weeks postoperatively
- Quality of life 3 months \pm 2 weeks postoperatively
- Intraoperative handling of the suture material
- Length of postoperative hospital stay

Quality of life was rated by the patients using the EQ-5D-5L questionnaire preoperatively, 30 days postoperatively and 3 months after surgery. EQ-5D-5L was used in the German, Spanish, Italian language and the sponsor has taken up a license at the EuroQol Group. EQ-5D is a standardised measure of health status developed by the EuroQol Group to provide a simple, generic measure of health for clinical and economic appraisal. EQ-5D is designed for self-completion by respondents and takes only a few minutes to complete. Instructions to respondents are included in the questionnaire. EQ-5D-5L consists of 2 pages – the descriptive system and the EQ Visual Analogue Scale (EQ-VAS). The descriptive system comprises 5 dimensions (mobility, self-care, usual activities, pain/discomfort, anxiety/depression). Each dimension has 5 levels: no problems, slight problems, moderate problems, severe problems and extreme problems. The EQ VAS records the respondents self-rated health on a 20 cm vertical, visual analogue scale with endpoints labelled “the best health you can imagine, points = 100” and “the worst health you can imagine, points = 0”.

Assessment of the intraoperative handling of the suture material was performed using a five-point Likert Scale (1 worst - 5 best). The following dimensions were evaluated: Knot security, elasticity, feel, tissue drag, and knot pull strength.

3. Results

3.1. Recruitment

More than 200 patients were screened. Inclusion of the first patient was performed on 30th November 2015. Recruitment of 199 patients was completed on 17th February 2017. Last patient out was completed on 8th May 2017.

Finally, the data set containing 199 patients was analysed. A flow chart is not provided due to the single-arm design of this cohort study.

One hundred and ninety-six patients were examined up to the day of discharge. The visit 30 days after surgery was performed for 188 patients because one patient died and the data of two patients were missing on the day of discharge. Between operation and 30 days post-operatively, a total of two deaths occurred and nine patients were lost to follow-up. A total of 191 patients were examined 3 months post-operatively. In total, 6 patients died from surgery up to 3 months postoperatively, and 2 patients were lost to follow-up at the 3-month visit.

3.2. Demography

A total of 154 men and 45 women were included. A mean BMI of $27.98 \pm 4.23 \text{ kg/m}^2$ was observed in the OPTICABG cohort [min. 18.37 kg/m^2 – max. 44.98 kg/m^2]. The average age was 67.24 ± 10.11 years [min. 39 years – max. 89 years]. Further baseline characteristics and reasons for surgery are shown in Tables 1 and 2.

3.3. Intraoperative and surgical details

In total, 24 surgeons participated in the study; 12 surgeons in the German hospital, and 6 surgeons each in the Italian and Spanish clinics. Most of the operations were performed by consultants (N = 148); only 33 interventions were performed by head physicians, and residents were involved in 18 operations. In total, 94% of the patients underwent a sternotomy; the remaining patients underwent minimally invasive surgery (mini-thoracotomy). This type of minimally invasive intervention was performed by all centres (10% Germany, Italy and Spain 4% each). In total, 58% of the patients underwent off-pump surgery, 40% on-pump surgery and 2% of the operations started off-pump and were

Table 1
Baseline characteristics.

	N	Percentage [%]
Smoker	46	23
ASA:		
ASA I	36	18
ASA II	38	19
ASA III	123	62
ASA IV	2	1
Hypertension	142	71
COPD	24	12
Stroke	12	6
Diabetes	60	30
Risk for renal insufficiency	15	8
Hyperlipidemia	141	71
Sinus rhythm	189	95
Atrial fibrillation	10	5
Left ventricular ejection fraction:		
< 21%	1	0.5
21%–30%	9	5
31%–50%	33	17
> 50%	156	78

Table 2

Cardiac disease and reason for surgery.

	N
Left main disease only	4 (2%)
Left main disease in combination a single vessel disease	0
Left main disease in combination with a double vessel disease	3 (1%)
Left main disease in combination with a multi vessel disease	20 (10%)
Single vessel disease only	17 (9%)
Double vessel disease only	32 (16%)
Multivessel disease only	123 (62%)
NYHA I	52 (26%)
NYHA II	95 (48%)
NYHA III	51 (25%)
NYHA IV	1 (1%)
Combined surgery no	167 (84%)
Combined with aortic valve replacement	16 (8%)
Combine with mitral valve repair	7 (3.5%)
Combined with mitral valve replacement	5 (2.5%)
Combined with aortic replacement, mitral valve repair	1 (0.5%)
Others	3 (1.5%)

then converted to on-pump surgery. In Germany, 91% of the interventions were performed off-pump, whereas on-pump surgery was preferred in Italy (67%) and Spain (58%). CABG surgery took on average $209.03 \text{ min} \pm 59.08 \text{ min}$ [min. 50 min – 420 min].

3.4. Anastomosis and bypass details

In total, 544 bypass interventions were performed in 199 patients. The average number of bypasses per patient was 3 [min. N = 1 – max. N = 6]. The LIMA was used as graft material in most of the bypasses followed by a radial artery, the RIMA and the saphenous vein. The LIMA was used as graft material in 95% of the patients.

The total number of anastomoses was 708; distal N = 544 and proximal N = 164. To construct the anastomosis, Optilene suture material was applied using USP 8/0, USP 7/0 or USP 6/0. The clinics in Germany and Spain preferred USP 8/0, whereas USP 7/0 was mainly used in Italy. USP size 6/0 was only used for proximal anastomoses not for distal anastomoses. The average number of applied suture threads per cardiac operation was 4 [min. N = 1 – max. N = 7].

The most often used vessel for distal anastomosis construction was the LAD (34%), followed by the CxMarg I (21%), the PDA (18%), the CxMarg II (11%), and DG I (10%). The LIMA was anastomosed to the LAD in 92% of the patients. All proximal anastomoses used either the LIMA (sequential bypass; N = 121 anastomoses) or the aorta (N = 36 anastomoses), or others (N = 7).

3.5. Outcomes

3.5.1. Primary outcome

Primary outcome was the incidence of early in-hospital CABG adverse events occurring up to day of discharge. In-hospital CABG adverse events were myocardial infarction, stroke, death, GI bleeding and renal failure.

Six CABG events occurred up to discharge: one death (haemorrhagic shock), two myocardial infarctions and three renal failures, leading to a CABG event rate of 3%; CI 95% [1.1%–6.5%]. This rate was compared to the literature reference of Nalysnyk et al. that showed a cumulative CABG event rate of 8.46% up to day of discharge. The reference value of 8.46% lies outside the corresponding 95% confidence interval for the OPTICABG study; thus, the 3% CABG event rate observed in the OPTICABG study was significantly lower.

In addition, we also compared our in-hospital MACCE adverse rate to the MACCE rate of the CABG group published in the SYNTAX trial in

Table 3
Safety parameters.

Complication	Discharge	30 days	3 months	Total
Death	1 (0.5%)	1	4	6 (4.5%)
Stroke	0 (0%)	0	0	0 (0%)
Myocardial Infarction	2 (1.0%)	0	1	3 (1.5%)
Renal failure	3 (1.5%)	0	1	4 (2.0%)
GIT bleeding	0 (0%)	0	0	0 (0%)
Total	6 (3.0%)	1	6	13 (9.8%)

2009 [12]. Within the SYNTAX trial the MACCE rate was defined as the combination of the death, stroke, myocardial infarction and revascularisation. Therefore, we performed an analysis of the same MACCE adverse event combination in our study. The following MACCE rate were reported for the SYNTAX CABG group: until discharge (in-hospital) 5.4%, in our study we observed a MACCE rate (1 death, 2 myocardial infarctions, 1 revision due to malfunction of the bypass; 4/199 patients) of 2.0% CI 95% [0.55%–5.1%] until discharge (in-hospital). Indicating that our MACCE rate was lower than in the SYNTAX trial, because the upper limit of our CI does not included 5.4%.

3.5.2. Secondary outcome: safety and efficacy parameters

3.5.2.1. Safety. One additional patient died (sepsis) within 30 days after surgery, and the total CABG rate increased to 3.5%, CI 95% [1.4%–7.2%]. By the end of the study, a total of six deaths, three myocardial infarctions and four renal failures were recorded, indicating a CABG rate of 9.8%; CI 95% [5.3%–16%] at 3 months after surgery (Table 3).

Reason for death was reported as follows: 2 x sepsis, 1 x respiratory failure, 1 x haemorrhagic shock, 1 x stroke and 1 x resuscitation.

Total number of adverse events was 48 in the OPTICABG study. Death rate was 4.5% (N = 6), renal failure rate 2.0% (N = 4), myocardial infarction rate 1.5% (N = 3). One stroke occurred at the 3-month follow-up and resulted in death. Therefore, this stroke was recorded under the death rate.

Reoperation was necessary in eight patients. In six patients this was due to a problem with the sternal wound; one revision was performed due to malfunction of the bypass; in another case, cardiac intervention with aortic valve replacement was necessary.

Postoperative bleeding, mainly haematomas with no causal relationship to the anastomosis, was seen in three patients resulting in further surgical interventions. A PCI was reported in 2 patients postoperatively.

Superficial wound infections classified as A1 were observed in four cases (2%) and a deep wound infection classified as A2 was seen in two patients (1%). Treatment was antibiotics. Number of other health disorders was 16 (data not shown).

Most of the adverse events were resolved (30/48): 8/48 AEs were resolved with sequelae; 2/48 were ongoing; for 2/48 the status was not recorded; and 6 events lead to death. In total, 31/48 AEs were rated as serious. Only 2 of the AEs reported were associated with the applied suture material (2 threads ruptured during knotting).

3.5.2.2. Efficacy. Length of postoperative hospital stay was 9.42 ± 5.03 days. A mean duration of 2.60 ± 2.38 days. [min. 1 – max. 17 days] was recorded for the stay in the intensive care unit.

Assessment of the intraoperative handling of the suture material was performed using a five-point Likert Scale (1 worst - 5 best). All dimensions were predominantly evaluated with four points, indicating that handling of the suture material is excellent and well-suited for CABG surgery (Fig. 1).

Quality of life was rated by the patient using the EQ-5D-5L questionnaire preoperatively, 30 days postoperatively and 3 months after surgery (“the best health you can imagine, points = 100” and “the

worst health you can imagine, points = 0”).

Preoperatively, the patients assessed their health as 65 ± 15.95 points. At 30 days postoperatively, this had increased to 70 ± 16.51 points, and to 80 ± 15.44 points at assessment 3 months after surgery (Fig. 2). A *t*-test indicated that Quality of life was significantly improved 3 months after surgery compared to status at screening. Further subgroup analysis of the five variable dimensions showed no significant difference at different time points.

3.6. Employment status

Employment status is recorded in Table 4. The total population consisted of approximately 50% retirees. More patients were able to work full-time from 30 days postoperative up to 3 months after surgery. Only 5% of the patients were unable to work 3 months postoperatively.

4. Discussion

CABG surgery is described as a safe concept and is a routinely performed operation in patients with coronary artery disease. It is the most common surgical procedure performed on the heart. Alexis Carrel described the principles of the CABG in 1910. In 1953, J. Gibbon performed the first heart-lung bypass and, in 1968, R. Favaloro used a saphenous vein graft for the first time as the coronary artery bypass graft. In the 1960s, the clinic of Kolesov was the only one in the world regularly performing CABGs. The first LITA graft performed on a beating heart was reported by Kolesov in 1964, but was soon abandoned [13].

In the 1990s this type of intervention underwent a revival after the work of Benetti.

Common, reported complications of CABG surgery are mortality (2–4%), myocardial infarction (2–4%), renal failure (30%), and bleeding (4–6%). The present prospective, international, multi-centric, observational cohort study was undertaken to assess the performance of a new suture material (Optilene®) in coronary artery bypass graft surgery using routine clinical procedures. The outcomes of subgroup analyses from the results published by Nalysnyk et al., in 2003 were pooled and gave the following complication rates for myocardial infarction (2.82%), stroke (1.93%), GI bleeding (1.28%), renal failure (requiring dialysis (0.7%), mortality (1.72%) and 30-day mortality (2.1%). The cumulative incidence of these CABG adverse events up to day of discharge was 8.46% which served as a reference in the current study. Our hypothesis was that if our MACCE rate is lower or equal to the reference rate, the suture material Optilene® can be regarded as a safe and efficient alternative to the existing sutures used for CABG surgery.

Cumulative CABG adverse event rate up to day of discharge was 3% in the present study compared to 8.46%. A *t*-test demonstrated that our CABG rate was significantly lower. Comparison of the incidence of individual CABG adverse events up to discharge also showed lower reported complication rates. Furthermore, the 30-day mortality rate was 1.0% in the current study and therefore lower than the reference value at 30 days postoperatively (2.1%). In addition, only one reoperation due to malfunction of the bypass was needed (0.5%) in the study group. An infection in the sternal wound was observed in 3% of the patients, and no anastomotic bleeding was seen. Only one stroke (1/197, 0.5%) occurred at 3 months postoperatively which led to death.

Comparison of the OPTICABG MACCE rate to the MACCE rate of the SYNTAX study published in 2009 [12], indicated that our MACCE rate until discharge was lower than in the SYNTAX trial 2.0% vs. 5.4% and comparable at 30 days postoperatively 2.5% vs. 5.2%, respectively.

In regard to safety, the type of adverse events – with varying severity and frequency – reported in the OPTICABG study are very common in patients with underlying conditions as encountered in this non-interventional study. Therefore, by using the mentioned parameter we could demonstrate the safety of Optilene® suture material for CABG

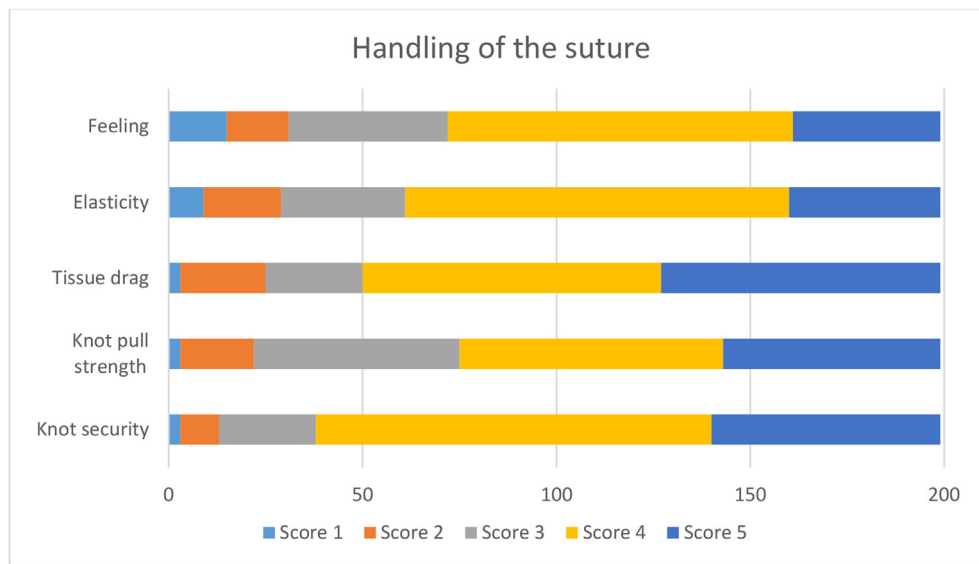


Fig. 1. Handling the suture.

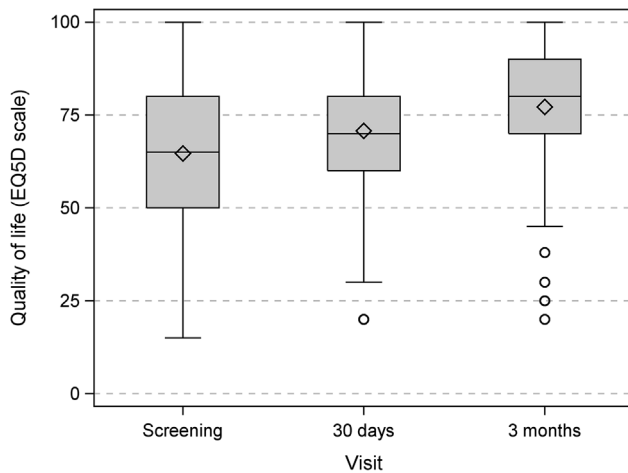


Fig. 2. Quality of life (EQ-5D-5L).

Table 4

Employment status.

	30 days	3 months
Able to work fulltime	9 (4.5%)	51 (26%)
Able to work part-time	52 (26%)	31 (15.5%)
Unable to work	35 (18%)	11 (5.5%)
Retired	92 (46%)	98 (49%)
Unkown	11 (5.5%)	8 (4%)

surgery.

In total, 708 anastomoses were constructed using Optilene® suture material with varying USP sizes. Handling of the suture thread was rated as very good. Quality of Life (QoL) significantly increased from preoperatively to 3 months postoperatively and the increase was independent of the hospital, the type of operation (off-pump or on-pump) or the type of chest opening (sternotomy or minimally invasive).

A typical population with cardiac disease was treated in our study. No severe risk factors could be identified. Hyperlipidaemia was reported in 71% of patients which is quite normal in this type of patient cohort. Hyperlipidaemia is the main reason for arteriosclerosis and calcification of the arterial vessels resulting in decreased blood supply.

Similarly to the literature, the LIMA was also predominantly used as graft material in our study. In most cases this was anastomosed to the LAD because these vessels have the same lumen and their characteristics match very well. Sternotomy was the preferred technique for opening the chest, but the minimally invasive approach was selected in 6% of the patients. The number of patients receiving off-pump or on-pump surgery were not significantly different, but a centre-specific effect in regard to off-pump surgery was noticed in Germany, where 91% of the interventions were performed as off-pump surgery in contrast to Italy (33%) and Spain (41%). Numerous surgeons (N = 24) with various functions located in three different European hospitals performed the cardiac surgery in a representative study population using daily routine clinical procedures. This indicates high transferability and generalisation of our clinical results. Nonetheless, our study has some limitations, such as the use of a historical control group and a short-term postoperative follow-up. A further weakness is the small cohort size.

In conclusion the OPTICABG study, which is a single-arm, multi-centre, international, prospective study has shown that the use of the Optilene® suture consisting of polypropylene 95% and polyethylene 5% is safe and efficient for CABG surgery in an unselected broad patient population with a cardiac disorder treated in clinical practice using either on-pump or off-pump surgery interventions. Therefore Optilene® suture represents a viable alternative for CABG interventions.

Ethical approval

Study was approved by the ethics committees responsible for the participating clinics.

Positive ethics approval was obtained by following Institutional Review Board.

Ethics Committee, University Tübingen; Germany.

Comité Ético de Investigación Clínica, Hospital de la Santa Creu i Sant Pau; Barcelona, Spain.

Ospedale Luigi Sacco, Comitato Etico Interaziendale Milano Area A, Italy.

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Aesculap AG was responsible for project management, data management, statistics and for study registration. Aesculap AG was involved

in the preparation of the manuscript, in the decision of journal selection and in the submission process of the manuscript.

Author contribution

Petra Baumann designed the study. Manel Tauron Ferrer, Monica Contino, Claudia Romagnoni performed the data collection. Viktor Breul (contributor) was responsible for data analysis. Petra Baumann wrote the manuscript. Manuscript was reviewed and approved by Adrian Ursulescu, Manel Tauron Ferrer, Monica Contino, Claudia Romagnoni, Carlo Antona, Josep Maria Padró Fernández.

Conflicts of interest

Petra Baumann is an employee of Aesculap AG.
Adrian Ursulescu, Manel Tauron Ferrer, Monica Contino, Claudia Romagnoni, Carlo Antona, Josep Maria Padró Fernández declare no conflict of interest.

Research registration number

Study was registered on the 11th September 2015 at www.clinicaltrials.gov under the registration number [NCT02546557].

Guarantor

Petra Baumann is the guarantor for this cohort study.

Consent

The authors declare that written informed consent has been obtained by all enrolled patients according to data protection law.

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Abbreviation list

AE	Adverse Event
ASA	American Society of Anaesthesiologists - Physical Health Status
BMI	Body Mass Index
CABG	Coronary Artery Bypass Graft
CAD	Cardiac Artery Disorder
COPD	Chronic Obstructive Pulmonary Disease
CxMarg	Left Circumflex Artery Marginal Branch
DG	Diagonal Artery
LAD	Left Anterior Descending Artery
LIMA	Left Internal Mammary Artery
NYHA	New York Heart Association
PDA	Posterior Descending Artery
PMCF	Post Market Clinical Follow up
QoL	Quality of Life
RIMA	Right Internal Mammary Artery

RA	Radial Artery
SAE	Serious Adverse Event
SVG	Saphenous vein graft

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2018.09.005>.

References

- [1] A.L. Hawkes, M. Nowak, B. Bidstrup, R. Speare, Outcomes of coronary artery bypass graft surgery, *Vasc. Health Risk Manag.* 2 (4) (2006) 477–484.
- [2] A.T. Ong, P.W. Serruys, F.W. Mohr, M.C. Morice, A.P. Kappetein, D.R. Holmes Jr., M.J. Mack, M. van den Brand, M.A. Morel, G.A. van Es, J. Kleijne, J. Koglin, M.E. Russell, The SYnergy between percutaneous coronary intervention with TAXus and cardiac surgery (SYNTAX) study: design, rationale, and run-in phase, *Am. Heart J.* 151 (6) (2006 Jun) 1194–1204.
- [3] F.W. Mohr, M.C. Morice, A.P. Kappetein, T.E. Feldman, E. Ståhle, A. Colombo, M.J. Mack, D.R. Holmes Jr., M.A. Morel, N. Van Dyck, V.M. Houle, K.D. Dawkins, P.W. Serruys, Coronary artery bypass graft surgery versus percutaneous coronary intervention in patients with three-vessel disease and left main coronary disease: 5-year follow-up of the randomised, clinical SYNTAX trial, *Lancet* 381 (9867) (2013) 629–638.
- [4] A. Lamy, P.J. Devereaux, D. Prabhakaran, D.P. Taggart, S. Hu, E. Paolasso, Z. Straka, Off-pump or on-pump coronary-artery bypass grafting at 30 days, *N. Engl. J. Med.* 366 (16) (2012 Apr 19) 1489–1497.
- [5] A. Lamy, P.J. Devereaux, D. Prabhakaran, D.P. Taggart, S. Hu, E. Paolasso, Z. Straka, L.S. Piegas, A.R. Akar, A.R. Jain, N. Noiseux, C. Padmanabhan, J.C. Bahamondes, R.J. Novick, P. Vaijyanath, S.K. Reddy, L. Tao, P.A. Olavegogeochea, B. Airan, T.A. Sulling, R.P. Whitlock, Y. Ou, J. Pogue, S. Chrolavicius, S. Yusuf, CORONARY Investigators Piegas LS, A.R. Akar, A.R. Jain, N. Noiseux, C. Padmanabhan, J.C. Bahamondes, R.J. Novick, P. Vaijyanath, S. Reddy, L. Tao, P.A. Olavegogeochea, B. Airan, T.A. Sulling, R.P. Whitlock, Y. Ou, J. Ng, S. Chrolavicius, S. Yusuf, C.O.R.O.N.A.R.Y. Investigators, Effects of off-pump and on-pump coronary-artery bypass grafting at 1 year, *N. Engl. J. Med.* 368 (13) (2013 Mar 28) 1179–1188.
- [6] A. Lamy, P.J. Devereaux, D. Prabhakaran, D.P. Taggart, S. Hu, Z. Straka, L.S. Piegas, A. Avezum, A.R. Akar, F. Lanus Zanetti, A.R. Jain, N. Noiseux, C. Padmanabhan, J.C. Bahamondes, R.J. Novick, L. Tao, P.A. Olavegogeochea, B. Airan, T.A. Sulling, R.P. Whitlock, Y. Ou, P. Gao, S. Pettit, S. Yusuf, C.O.R.O.N.A.R.Y. Investigators, Five-year outcomes after off-pump or on-pump coronary-artery bypass grafting, *N. Engl. J. Med.* 375 (24) (2016 Dec 15) 2359–2368.
- [7] A.L. Shroyer, F.L. Grover, B. Hattler, J.F. Collins, G.O. McDonald, E. Kozora, J.C. Lucke, J.H. Baltz, D. Novitzky, Veterans Affairs randomized on/off bypass (ROOBY) study group. On-pump versus off-pump coronary-artery bypass surgery, *N. Engl. J. Med.* 361 (19) (2009 Nov 5) 1827–1837.
- [8] A.L. Shroyer, B. Hattler, T.H. Wagner, J.F. Collins, J.H. Baltz, J.A. Quin, G.H. Almassi, E. Kozora, F. Bakaeen, J.C. Cleveland Jr., M. Bishawi, F.L. Grover, Veterans Affairs ROOBY-FS group. Five-year outcomes after on-pump and off-pump coronary-artery bypass, *N. Engl. J. Med.* 377 (7) (2017 Aug 17) 623–632.
- [9] A. Diegeler, J. Börgermann, U. Kappert, M. Breuer, A. Böning, A. Ursulescu, A. Rastan, D. Holzhey, H. Treede, F.C. Rief, P. Veeckmann, A. Asfoor, W. Reents, M. Zacher, M. HilkerGOPCABE Study Group, Off-pump versus on-pump coronary-artery bypass grafting in elderly patients, *N. Engl. J. Med.* 368 (13) (2013 Mar 28) 1189–1198.
- [10] L. Nalysnyk, K. Fahrbach, M.W. Reynolds, S.Z. Zhao, S. Ross, Adverse events in coronary artery bypass graft (CABG) trials: a systematic review and analysis, *Heart* 89 (7) (2003 Jul) 767–772.
- [11] R.A. Agha, M.R. Borrelli, M. Vella-Baldacchino, R. Thavayogan, D.P. Orgillfor the STROCSS Group, The STROCSS statement: strengthening the reporting of cohort studies in surgery, *Int. J. Surg.* 46 (2017 Sept) 198–202.
- [12] P.W. Serruys, M.C. Morice, A.P. Kappetein, A. Colombo, D.R. Holmes, M.J. Mack, E. Ståhle, T.E. Feldman, M. van den Brand, E.J. Bass, N. Van Dyck, K. Leadley, K.D. Dawkins, F.W. Mohr, S.Y.N.T.A.X. Investigators, Percutaneous coronary intervention versus coronary-artery bypass grafting for severe coronary artery disease, *N. Engl. J. Med.* 360 (10) (2009 Mar 5) 961–972.
- [13] M. Diodato, E.G. Chedrawy, Coronary artery bypass graft surgery: the past, present, and future of myocardial revascularisation, *Surg. Res. Pract.* 2014 (2014) 726158.