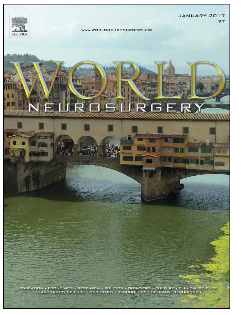
Accepted Manuscript



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PII: S1878-8750(18)32075-8

DOI: 10.1016/j.wneu.2018.09.031

Reference: WNEU 9137

To appear in: *World Neurosurgery*

Received Date: 17 July 2018

Revised Date: 1 September 2018

Accepted Date: 4 September 2018

Please cite this article as: Hafez A, Huhtakangas J, Sajjad M, Lawton MT, Tanikawa R, Niemelä M, The identification of factors that influence the quality of bypass anastomosis and an evaluation of the usefulness of an experimental practical scale in this regard, *World Neurosurgery* (2018), doi: https://doi.org/10.1016/j.wneu.2018.09.031.

The identification of factors that influence the quality of bypass anastomosis and an evaluation of the usefulness of an experimental practical scale in this regard

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Conflict of Interest: The authors have no conflict of interest related to the content of this manuscript

Disclosure of funding: The study received no funding.

Key Words: Bypass, Anastomosis, practical Scale.

Acknowledgement:

1. The authors would like to thank the following neurosurgeons for independently assisting in reviewing and evaluating the cases:

Ahmed Alsherkawi, MD, PhD: Tanta University, Egypt.

Ayman Al-Shayji, MD: Saint John Regional Hospital, Canada.

Ferzat Hijazy, MD: BG Klinikum Bergmannstrot, Halle, Germany.

Johannes Dillmann, MD: Diakoine Klinikum GmbH., Germany.

Joseph Serrone, MD: Loyola University Medical Center, USA.

2. Part of this study presented during (THE 18TH HELSINKI LIVE DEMONSTRATION COURSE IN OPERATIVE MICRONEUROSURGERY), June 3-8, 2018 | Helsinki, Finland.

3. Several points had been developed after analyzing live and recorded surgeries of revascularization, which had been done by two authors in this paper; Dr. Rokuya Tanikawa and Dr. Michael T. Lawton.

4. Third author (S.M.) was awarded a scholarship for his Clinical Fellowship Program at the department of Neurosurgery in Helsinki from C. Ehrnrooth Foundation. The sponsors had no role in the design or conduct of the research.

Abstract

Background: Several factors associated with interrupted and continuous suturing techniques affect the quality of bypass anastomosis. It is difficult to determine the impact of these during surgery. Thus, the primary study objective was to evaluate factors with the potential to influence the quality of bypass anastomosis using either interrupted or continuous suturing. A secondary objective was to evaluate the usefulness of a practical scale when comparing interrupted and continuous suturing techniques, in order to improve bypass anastomosis.

Method: Interrupted ($n = 100$) and continuous ($n = 100$) suturing techniques were used in 200 end-to-side bypasses to a depth of 3 cm and were assessed by five external neurosurgeons.

Results: Vessel closing time ($p = < 0.001$), stitch distribution ($p = < 0.001$), (intima-intima attachment) ($p = < 0.001$) and the size of the orifice ($p = < 0.001$) had a significant impact on the quality of the bypass, irrespective of the suturing technique used. The suturing technique used (interrupted or continuous) and positioning of the recipient vessel (vertical or horizontal) did not significantly influence the quality of anastomosis. The highest statistical significance was attributed to the large size of the orifice and intimal attachment with regard to bypass quality using multivariate analysis.

Conclusion: There were advantages and disadvantages to both suturing techniques. The scale was a practical way of measuring and improving performance.

Abbreviations:

Ch. Co. H: Chicken vessel continuous horizontal positioning

Ch. Co. V: Chicken vessel continuous vertical poisoning

Ch. In. H: Chicken vessel interrupted horizontal positioning

Ch. In .V: Chicken vessel interrupted vertical positioning

CI: Confidence interval.

OR: Odds ratio

ROC curve: Receiver Operating Characteristic curve.

TSIO: Time, Stitch, Intima, Orifice

Wt. Co. H: Wet tube continuous horizontal positioning

Wt. Co. V: Wet tube continuous vertical poisoning

Wt. In. H: Wet tube interrupted horizontal positioning

Wt. In. V: Wet tube interrupted vertical positioning

Introduction

Vital steps need to be taken to ensure the quality of vascular anastomosis during bypass surgery.[1-11] It is critical to ensure that the time taken to minimise blood flow during the procedure is as brief as possible as this is a significant source of stress for the neurosurgeon[12,13] and can impact on the quality of suturing.

Several factors, including stitch-related leakage, orifice and lumen stenosis, and contact between the naked thread and the blood (with the potential for the development and stasis and thrombosis) can impact on short- and long-term functioning of the bypass.

There is support for interrupted and continuous suturing as both have advantages and disadvantages.[14-17] The use of continuous suturing could reduce the duration of the procedure. It is likely that the extent of blood leakage is less with continuous than with interrupted suturing owing to the exertion of compression circumferentially. However, maintaining symmetrical distribution of the sutures is challenging because the thread is stretched. There is also the potential for the development of stenosis of the orifice and lumen using this approach. The compromise between increased stretching (which causes stenosis) and reduced stretching (which causes loose anastomosis and leakage) adds uncertainty to the procedure. Ensuring intimal attachment and preventing exposure of the thread or suture material inside the lumen and direct contact with the blood should be performed to prevent future stasis and thrombosis. The inability to do this is a disadvantage of continuous suturing. In order to bury the thread inside the wall, it is necessary to stretch it but this places the anastomotic orifice at risk of stenosis.

An advantage of interrupted suturing in anastomosis is that it has higher possibility to achieve intimal attachment by applying inverted technique of the anastomosis edges, and to prevent the exposure of the thread to blood inside the lumen. Most surgeons require extra time to complete the procedure as a result. Ensuring the equitable distribution of stitches can help to improve the quality of anastomosis by facilitating a wider orifice and lack of contract between the thread and bloodstream.

Technically, the quality of anastomosis during live surgery cannot be directly evaluated and is usually assessed by indocyanine green (ICG), microvascular Doppler, or intraoperative angiography. However, this approach does not guarantee the physical and technical quality of the bypass in the long-term. Furthermore, bypass surgery is highly specialised, is not performed in every day practice and cannot feasibly be taught in the operating theatre. Therefore, mandatory validation of the quality of anastomosis using laboratory and experimental testing is required.

End-to-side anastomosis, a microsurgical technique, is the most common bypass procedure that is performed by neurosurgeons. Thus, the primary study objective was to identify factors that influence the quality of bypass anastomosis. A secondary objective was to evaluate the usefulness of a practical scale in comparing interrupted and continuous suturing techniques, with the aim of improving bypass anastomosis.

Materials and Methods

For the aim of this study, only end-to-side anastomosis was performed and the most common superficial temporal artery to medial cerebral artery bypass was simulated. Two hundred anastomosis procedures were carried out to a depth of 3 cm using interrupted (*n* = 100) and continuous (*n* = 100) suturing. One-millimetre-wide vessels derived from chicken wings (*n* = 100) as well as 1-mm-wide wet tubes (*n* = 100) were used.

To simulate genuine surgical circumstances, the recipients were positioned vertically in half and horizontally in the other half of cases. The eight subgroups were:

- Chicken vessel-derived bypass using interrupted suturing and vertical positioning (Ch. In. V) (*n* = 25).
- Chicken vessel-derived bypass using interrupted suturing and horizontal positioning (Ch. In. H) (*n* = 25).
- Chicken vessel-derived bypass using continuous suturing and vertical poisoning (Ch. Co. V) (*n* = 25).
- Chicken vessel-derived bypass using continuous suturing and horizontal positioning (Ch. Co. H) (*n* = 25).
- Wet tube-based bypass using interrupted suturing and vertical positioning (Wt. In. V) (*n* = 25).
- Wet tube-based bypass using interrupted suturing and horizontal positioning (Wt. In. H) (*n* = 25).
- Wet tube-based bypass using continuous suturing and vertical poisoning (Wt. Co. V) (*n* = 25).
- Wet tube-based using continuous suturing and horizontal positioning (Wt. Co. H) (*n* = 25).

There were 20 stitches per anastomosis. The interrupted and continuous sutures were made with a 10-0 microvascular suture needle (Muranaka Medical Instruments, Tokyo, Japan), using a thread cut to a length of 5–6 cm at the start of each bypass procedure. The suturing was performed in the same order, i.e., two hanging sutures on the axial ends of the bypasses, followed by the application of two additional hanging sutures to the middle of both sides to form a diamond shape (Figure 1, Video 1). Two SuperBypass® (SB-1607) forceps (TAKAYAMA Instrument, Inc), a pair of scissors (Kamayama), a YASARGIL® Aesculap, Inc. Clip System (Aesculap) and two temporary clips comprised the main surgical instruments used.

Webcam C930e® (Logitech, Lausanne, Switzerland) was connected to the microscope and a MacBook Pro® (Apple Inc., Cupertino, USA). The video (720p video quality) was captured using QuickTime® (Apple Inc.) Suturing times were determined from the video playback.

Five neurosurgeons from institutes outside of Finland each analysed 200 slides, in which two of the best screen shots taken at the end of the bypass were included after the anastomosis procedure had been performed and which highlighted the stitches placed outside and inside the lumen.

Initially, the practical scale was applied to assess the time taken to complete the anastomosis using continuous and interrupted suturing, determined using the same approach as that used during real surgery, i.e., using temporary clips (Figures 2 and 3. The time taken for both techniques was determined from the recorded video (that was not edited). A score of 0 was given if the time taken to complete the surgery took ≥ 20 minutes and a score of 1 was conferred if it took ≤ 20 minutes.

The distribution of stitches on the wall of the vessel was the second factor that was assessed. A score of 1 was given for the favourable and symmetrical distribution of stitches and a score of 0 was conferred for unfavorable distribution (Figure 4 A and B).

Thereafter, the impact of intimal attachment on the quality of anastomosis was evaluated, judged according to whether or not the thread could be seen inside the lumen. A score of 1 was awarded if it could not be seen and a score of 0 if it could (Figure 5A and B).

Thereafter, the size of the orifice was considered. A score of 1 was awarded if the orifice was equal to or wider than the diameter of the recipient vessel and a score of 0 was given if it was not (Figure 6A and B).

The suturing technique (i.e., interrupted and continuous) used was also investigated as a key factor with the potential to influence the quality of anastomosis, together with positioning of the recipient vessel (vertical or horizontal) and the type of material used (i.e., a wet tube or chicken wing vessel). However, as the same distribution of materials were used in both groups, a decision was taken to exclude the latter as its impact was obvious owing to the difference in texture.

Statistical analysis

Statistical analysis was performed using Statistical Package for the Social Sciences® version 24 (SPSS Inc., Chicago, USA). Pearson's chi-square test and binary logistic regression were used to predict the relationship between variables and the proposed scale. A probability (*p*) value of < 0.050 was considered to be statistically significant. The Wald stepwise backward elimination procedures in logistic regression were used with selection variables based on the magnitude of their probability values (<0.1).

By comparing the area under the receiver operative characteristic (ROC) curves for the factors in relation to the practical scale results, we evaluated the power of prediction for all variables. For the area under ROC, 0.5 is considered indifferent, while 1 indicates full discrimination.

Results

Of the 1500 cases, the evaluated factors in the 200 samples were stratified using a scale (Table 1) so that a comparison could be made of the quality of the bypasses achieved using the two techniques. Detailed information about the 200 bypass procedure is shown in Table 2.

As an experimental constructive procedure done by suturing, direct evaluation of perfection by cutting the donor close to the orifice and examine the quality based on observation helped us in introducing the relevant elements of what we considered a good or failure bypass. Studying considerable number of our experimental bypasses supported the observation. We analyzed hundred cases in term of better construction anastomosis. The multivariable logistic model was constructed to test the association of combined predictor variables with the better construction. A simple practical scale was developed from the data which combined vessel closing time, distribution of the stitches, size of the orifice, and intima- intima attachment. We constructed a practical scale, which include only statistically significant variables. Points were assigned for time of closing the vessels, size of the orifice compared by the size of the recipient, symmetric distribution of the stitches, and intima-intima attached judged by not seeing the thread inside the lumen. The grade range from I to IV. A good bypass had higher grade (III& IV). Grade I& II considered unfavorable (Table1&2). A significant difference between the use of interrupted or continuous suturing was not demonstrated in the current study with respect to the impact of either on the quality of anastomosis.

The relationship between the individual factors and the suturing technique used is depicted in Table 3.

For favorable bypass outcome, significant factors were intima-intima attachment (P = <0.001; OR 31.8, and large orifice size (P = <0.001; OR 55.30) (Table 4).

Discussion

The quality of the stitching is an important factor to evaluate when seeking to determine the quality of the anastomosis. It is important to perform laboratory testing as the surgical expertise of neurosurgeons derives from experimental training and technical preparation. Many factors with the potential to impact on the quality of the anastomosis cannot be evaluated directly during surgery in the operating theatre. A simple and experimentally applicable grading system that is designed to predict the quality and ability of the anastomosis to endure is proposed. The bypass should be graded according to time taken to perform the anastomosis, the distribution of the stitches, intimal attachment and the size of the orifice. Ideally, an anastomosis bypass should be completed within 20 minutes, the stitches should be symmetrical, should feature initial attachment and a wide orifice (Video 1)[18,19]. The retrospective application of this grading scheme to a series of experimental bypass procedures was shown to accurately reflect the quality of anastomoses. The application of a standardised grading scheme would enable a comparison to be made of the results of various experimental bypass surgery training programmes and between different surgical techniques, and would also assist with the development of hand-eye coordination.

Four variables (TSIO) were identified as useful for inclusion in the practical scale employed in the current study to analyse 200 experimental end-to-side bypasses. The scale was simple to use (involving an easy scoring system), was easily applied and was predictive of anastomosis quality. The area under the ROC curve for was ≥ 70 for intima-intima attached, and for wide orifice (Figure 7).

A significant difference between the use of interrupted or continuous suturing was not demonstrated in the current study with respect to the impact of either on the quality of anastomosis. This elucidates why both techniques are used by neurosurgeons.[5,11,20]

The time taken to perform the bypass

Ensuring that the vessel is closed timeously in a bypass procedure is stressful for the surgeon as delays are associated with adverse brain effects. However, the performance and quality of the bypass are more relevant than stitching the vessels within the stipulated timeframe (of 20 minutes). However, the time taken to do so is used as a measure against which the speed at which improvement takes places is determined in training.[21,22]

Actions that do not fulfil their objective and time taken to perform the bypass

Actions that do not achieve their objective consume time and, more importantly, disturb eye-hand orientation, the flexibility of the surgeon and self-confidence.[2,3,13,23,24] Although time is always measured during a bypass procedure, it is difficult to quantify the most optimal cut-off. The criterion of speed is not as important as the achievement of speed in combination with the other evaluated factors, i.e., achieving a score of 1 for completing the procedure in ≤ 20 minutes is more valuable when integrated with the other important criteria. Completing the procedure within ≤ 20 minutes impacted on the technical ability learning curve. In the current study, the procedure was completed quicker using continuous rather than interrupted suturing (a mean of 16.3 minutes vs. 19.9 minutes, respectively) (Figures 5 and 6).

Distribution of the stitches

The distribution of the stitches was somewhat predictable using the scale. Knotting each stitch in place, one at a time, using interrupted suturing helped with the equitable distribution of stitches along the vessel wall. Furthermore, the relationship between the donor and recipient vessel was established from the first two stitches and was maintained with the addition of each stitch (Video 1, Figure 1 A and B). By contrast, tightening the loose spiral suture and stretch suturing run, as well as overtightening the end before tying to close the gap between the two edges to prevent leakage, alters the relationship between the stitches on both sides. Neurosurgeons who use continuous suturing tend to apply an excess of stitches to avoid leakage at the end. However, they also take more time to carefully tighten each stitch in place at the end which can improve stitch matching between the donor and the recipient vessel. Additional challenges of this technique occur when a broken suture is inserted in the middle of a continuous suture line which requires extra work to repair or when the wall tears, leaving a gap that needs to be fixed at the end using extra interrupted stitches.

Intimal attachment

Ensuring intimal attachment is vital but cannot be evaluated during real-life surgery. The goal is to make sure that the thread is embedded inside the vessel wall, i.e., cannot be seen. This could have long-term consequences. For example, stasis and thrombosis can result from direct contact between the suture material and the blood.[25,26] This factor can only be assessed in an experimental bypass.

On completion of the procedure, the donor vessel that is cut close to the suture line. The inside of the lumen is then examined to determine if the thread can be seen in any of the stitches (Video 1, Figure 2 B). The walls of the vessels have to flip out (invert technique) to achieve Intima-intima tight attachment, which is the goal so that the thread is not visible inside the lumen. Following an evaluation of several bypass surgeries and available materials, it was found in the current study that interrupted suturing was able to successfully achieve intimal attachment without scarifying the size of the orifice.

Orifice size

It is possible to estimate the size of the orifice during real-life surgery. Blood flow through it can be gauged using ICG, microvascular Doppler imaging or intraoperative angiography. Nevertheless, it cannot determine the real size of the bypass opening (orifice). Being assured of the dimensions of the orifice in relation to the diameter of the vessel is a good approach to ensuring the future success of anastomosis. Our data showed a correlation between the surgical technique and the size of the orifice. It was convenient to apply a “tent construction technique” (Video 1) using interrupted suturing by starting at the donor vessel and moving to the recipient vessel. An association was observed between the distribution of stitches, intimal attachment and orifice size.

Use of the proposed practical scale

The technical difficulties of performing individual bypasses were highlighted by the proposed scale. Virtually all of them were completed without much difficulty using training of a reasonable level. However, greater attention and extra time was often required to effect wet tube and axis positioning of the recipient vessels.

This scale was designed to predict the outcome of a real-life bypass, based on the level of skill executed during experimental anastomosis. Laboratory testing is accepted as the gold standard when performing a bypass as it is the only means of estimating surgical ability and the risk of real-life anastomosis failing.[21] Repeating the anastomosis is adding extra difficulty to the procedure, and most of the patients suffer a stroke or worsening neurological deficits in short time.[27,28]

Unfit bypass also fail to provide protection from subsequent complications.[29] Even in cases where intraoperative patency of the anastomosis has been demonstrated, there is no assurance that occlusion will not occur in the future. In such cases, the potential for delayed occlusion of the bypass exists.

The proposed grading scale can be applied to different types of anastomosis; i.e., end-to-side, side-to-side and end-to-end. However, it is quite possible that this scale will not accurately predict the results of these three types of anastomosis at the same level as the related techniques differ among them and among neurosurgeons.

To improve performance based on the identified factors, several recommendations are offered regarding the development of hand skills, the reduction of unnecessary actions and the achievement of stress free performance (Video 1).

The prospective application of this grading scale in experimental bypass anastomosis is currently being considered. If this scale, is in its simplicity, is capable of predicting anastomosis quality in other training-based studies, it will be useful tool for an evaluation of anastomosis quality, with a view to improving performance in real-life bypasses.

Limitations

There were some limitations to the current study. It could be argued that consensus as to good distribution of the stitches is subjective. However, the same procedures were performed for all cases by the same reviewers and the same images were seen using the same magnification. Greater objectivity was possible when evaluating whether or not the thread could be seen inside the lumen and when determining the orifice diameter against the vessel diameter. Nevertheless, consensus was reached in this regard, and for all of the factors, for the vast majority of samples.

Theoretically, the use of one neurosurgeon could have affected the ability to generalise the findings. However, this was necessitated by the study aim and the need to develop a scale in order to decrease any confounding factors.

Conclusion

The study demonstrates the applicability of the practical scale for measuring and improving the performance. It provides opportunities for trainees to acquire and practice their skill in close to realistic environment.

The two main suture techniques (continuous and interrupted) showed similar final result according to our scale, however with a different distribution of the related factors.

Acknowledgement

1. The authors would like to thank the following neurosurgeons for independently assisting in reviewing and evaluating the cases:

Ahmed Alsherkawi, MD, PhD: Tanta University, Egypt.

Ayman Al-Shayji, MD: Saint John Regional Hospital, Canada.

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4. Third author (S.M.) was awarded a scholarship for his Clinical Fellowship Program at the department of Neurosurgery in Helsinki from C. Ehrnrooth Foundation. The sponsors had no role in the design or conduct of the research.

Figures legend

Figure 1. Diamond shape. Four basic stiches. The 4 big arrows represents the one anchoring stitch and one heel stitch, and the two sides (wings) stitches. The direction of the small arrows demonstrates the direction of stitching to achieve wide orifice (principle of tent design) and intima-intima attachment.

Figure 2. Frequencies of the consumed time in interrupted suturing technique in 100 bypasses.

Figure 3. Frequencies of the consumed time in continuous suturing technique in 100 bypasses.

Figure 4A. Good distribution of the stiches.

Figure 4B. Bad distribution of the stitches.

Figure 5A. No thread can be seen inside the lumen (perfect intima-intima attach).

Figure 5B. Thread is seen inside the lumen.

Figure 6A. Wide base of the bypass (good orifice).

Figure 6B. Narrow base of the bypass (narrow orifice).

Figure 7. The result of the test of the Area Under the Curve; interrupted or continuous 0.500, positioning of the recipient 0.553, closing (time consumed) 0.677, quality of stitches distance and distributing 0.683, not seeing the thread inside lumen 0.837, wide of the orifice 0.720. Reference line (interrupted light green), interrupted or continuous (light blue overlapping over the reference line), Positioning of the recipient (green), Consuming closing time (blue), distributing of the stitches (purple), Orifice size (red), and intima-intima attachment (black).

Table Legend

Table 1.

Grades = [Time consuming<20 minutes] + [good distributing of stitches] + [not seeing the threat inside lumen] + [wide of the orifice] (TSIO).

Practical Scale (TSIO) for bypass training. The best score is 4. One point for closing time less than 20 minutes. For the quality of the procedure; one point for good distributing of the stitches, one point for intima to intima contact (no thread is seen) looking inside the lumen, and one point for having orifice equal / or wider than the diameter of the vessel.

Table 2.

Characteristics of the anastomosis: Related information of bypass anastomosis in 200 recorded samples. The scoring result using the Practical Scale. Favorable result considered when the grade score is III or IV.

Table 3.

Gross analysis between the surgical technique and negative result of the survey for the four elements of the practical scale.

Table 4.

Factors significantly associated with favorable outcome in multiple logistic regression model (Wald stepwise backward model)

Refereces

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Table 1.

Practical Scale for evaluating the quality of the anastomosis	
Consuming Time for (20 stitches in 1mm vessel)	**Points**
<20 min	1
>20 min	0
Good distributing of the stitches	
Yes	1
No	0
Thread hidden inside the lumen (intima to intima contact)	
Yes	1
No	0
width of the orifice (equal or wider than the diameter of the vessel)	
Yes	1
No	0

Table 2. Characteristics of the anastomosis

Characteristics of the sample and Score Result of 200 training bypasses according to the Practical Scale								
	100 bypasses on wet tube (1mm tube, 20 stitches)				**100 bypasses on chicken wing (1 mm vessel, 20 stitches)**			
	Interrupted stitches (50)		**Continuous stitches (50)**		**Interrupted stitches (50)**		**Continuous stitches (50)**	
	Vertical Recipient (25) %	**Horizontal Recipient (25) %**	**Vertical Recipient (25)%**	**Horizontal Recipient (25)%**	**Vertical Recipient (25)%**	**Horizontal Recipient (25)%**	**Vertical Recipient (25)%**	**Horizontal Recipient (25)%**
Time for (20 stitches in 1mm vessel)								
>20 m	13(52%)	12(48%)	1(4%)	0	6 (24%)	7 (28%)	0	0
<20 m	12 (48%)	13 (52%)	24 (96%)	25 (100%)	19 (76%)	18 (72%)	25(100%)	25(100%)
Good distributing of the stitches								
Yes	18 (72%)	21 (84%)	17 (68%)	19 (76%)	100 (100%)	23 (92%)	19 (76%)	17(64%)
No	7 (28%)	4 (16%)	8 (32%)	6 (24%)	0	2 (8%)	6 (24%)	8 (32%)
Thread hidden (intima to intima attached)								
Yes	13 (52%)	18 (72%)	9 (36%)	16 (64%)	17 (68%)	20 (80%)	21 (84%)	19 (76%)
No	12 (48%)	7 (28%)	16 (64%)	9 (36%)	8 (32%)	5 (20%)	4 (16%)	6 (24%)
Size of the orifice (equal or wider than the diameter of the vessel)								
Yes	23 (92%)	24 (96%)	16 (64%)	19 (76%)	24 (96%)	25 (100%)	23 (92%)	20 (80%)
No	2 (8%)	1 (4%)	9 (36%)	6 (24%)	1(4%)	0	2(8%)	5 (20%)
The Score according to the Practical Scale								
IV	6 (24%)	7 (28%)	6 (24%)	12 (48%)	13(52%)	16 (64%)	15 (60%)	13 (48%)
III	8(32%)	12 (48%)	7 (28%)	7(28%)	9 (36%)	5 (20%)	5(20%)	7(32%)
II	7(28%)	5(20%)	9(36%)	4 (16%)	3(12%)	3 (12%)	1(4%)	3(4%)
I	4(12%)	1(4%)	3(8%)	2(8%)	0	1 (4%)	0*	2
Estimated good outcome (III&IV)								
III&IV	14(56%)	19 (76%)	13 (52%)	19 (76%)	22 (88%)	21 (84%)	20 (80%)	20 (80%)

*Few cases (less than 5%) where two or more of five of the observers could not give definite evaluation for certain elements from the figures. In these cases the judgment was done by going back to the recorded video

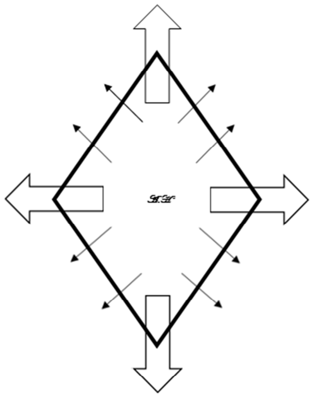
Table 3.

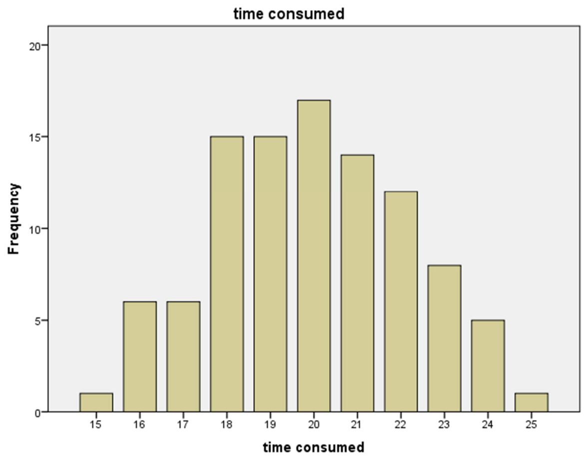
Negative findings and percentage of 200 bypass procedure				
	Closing time >20 min	Bad distribution of the stitches	Thread inside the lumen	Orifice narrower than the vessel
Number of cases	39 (19%)	41 (21%)	67 (34%)	26 (13%)
interrupted stitch	38 (97%)	13 (32%)	32 (48%)	4 (15%)
Continuous stitch	1 (3%)	28 (68%)	35 (52%)	22 (85%)

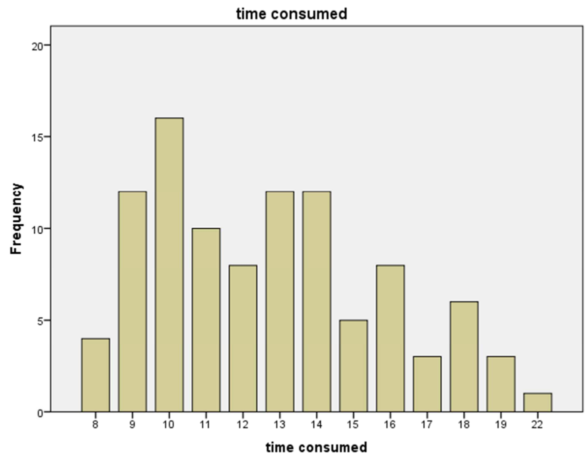
Table 4.

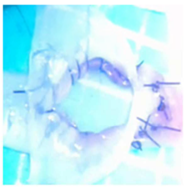
Factor	P value	OR	95 % CI
Intima-Intima Attachment	<0.001	31.82	10.30- 98.28
large Orifice Size	<0.001	55.30	10.94- 279.68

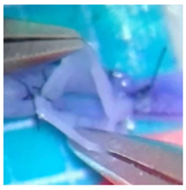
OR = Odds ratio, CI = Confidence interval.

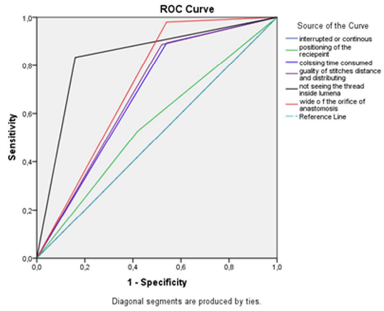



time consumed
Frequency
20
15
10
5
0
15
16
17
18
19
20
21
22
23
24
25
time consumed


time consumed
Frequency
20
15
10
5
0
8
9
10
11
12
13
14
15
16
17
18
19
22
time consumed






ROC Curve
Sensitivity
1 - Specificity
0,0
0,2
0,4
0,6
0,8
1,0
Source of the Curve
interrupted or continous
positioning of the reciepeint
colssing time consumed
guality of stitches distance and distributing
not seeing the thread inside lumena
wide o f the orifice of anastomosis
Reference Line
Diagonal segments are produced by ties.

Highlights:

1- The quality of the stitching is an important to determine the quality of the anastomosis.

2- Many factors with the potential to impact on the quality of the anastomosis cannot be evaluated directly during surgery in the operating theatre.

3- Four variables (TSIO) were identified.

4- A simple and experimentally applicable grading system that is designed to predict the quality and ability of the anastomosis to endure is proposed.