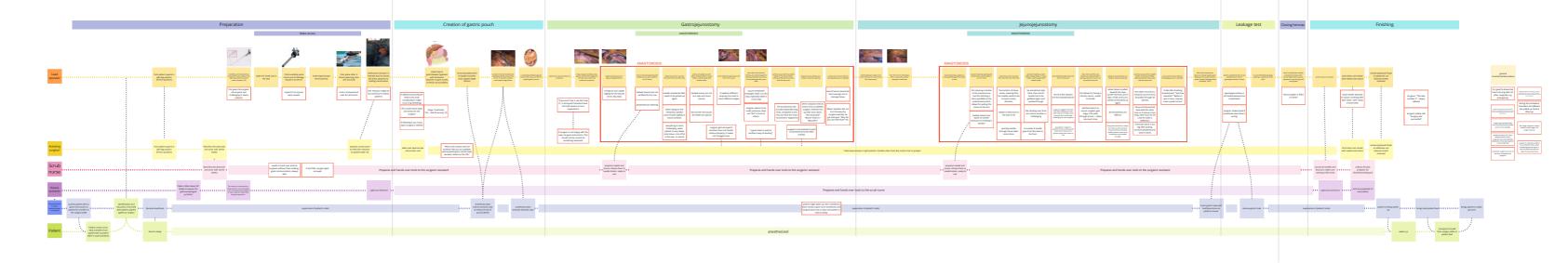
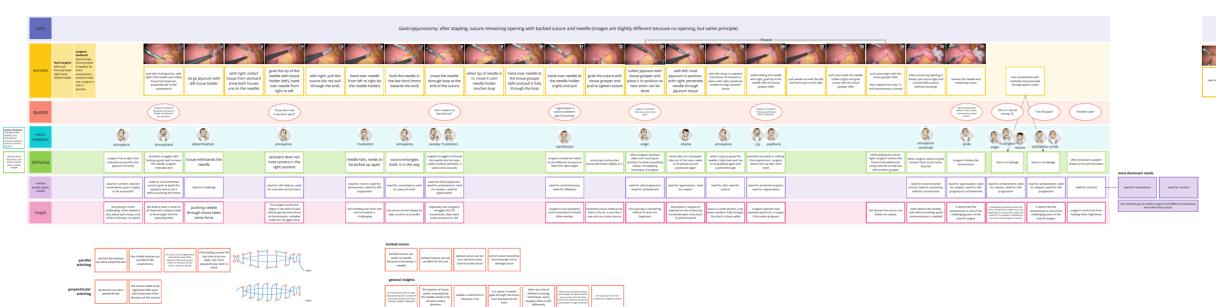
C: User experience workflow: Gastric Bypass

D: User experience workflow: Hand suturing

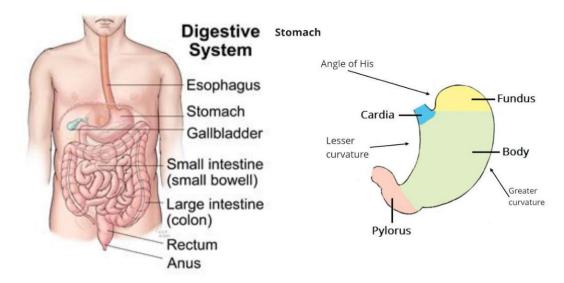


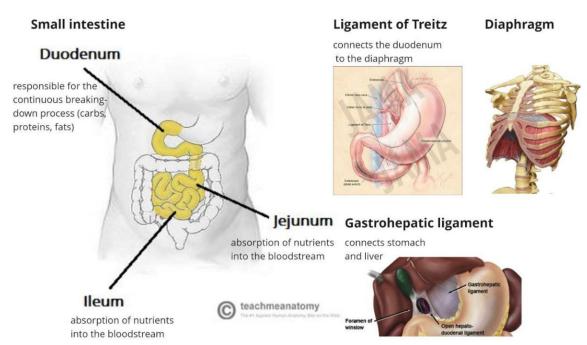


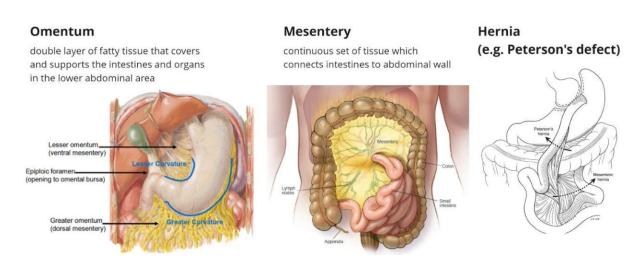
para date to the worlds. The date of the worlds and the world to the

Intracorporeal knot tying technique

Appendix E: Additional information about bowel anastomosis

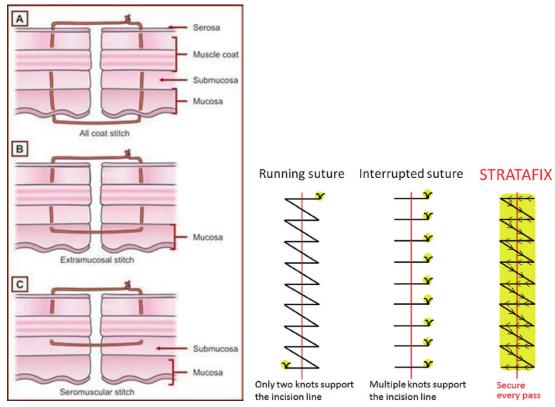






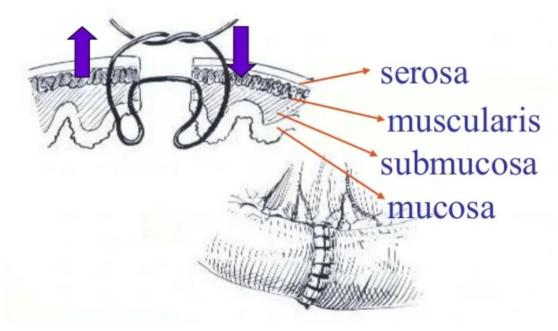
Appendix F: Suturing and knot tying techniques

Suture depth



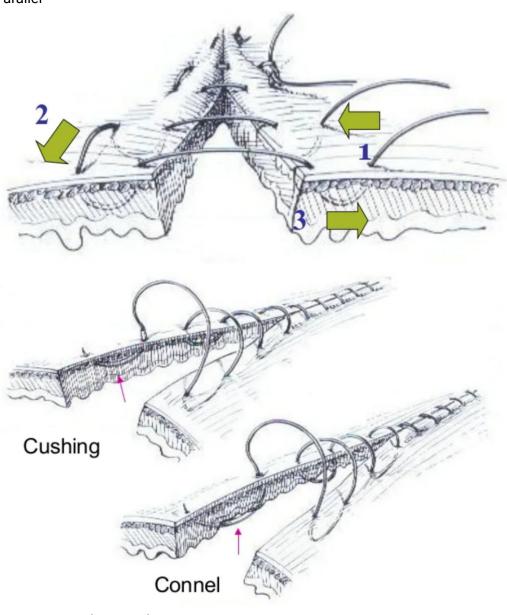
https://www.jaypeedigital.com/book/9788184484083/chapter/ch7
https://www.researchgate.net/publication/321207128_STRATAFIX_for_Abdominal_Wall_Repair_following_Abdominal_Flap_Harvest

Gambee suture

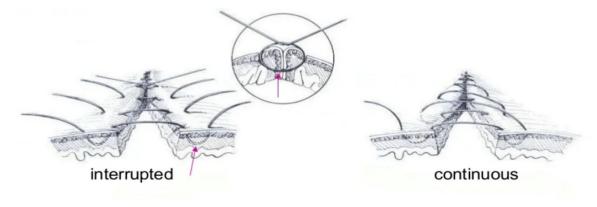


https://www.slideshare.net/drsatyajeetsingh/basic-suture-patterns

Parallel

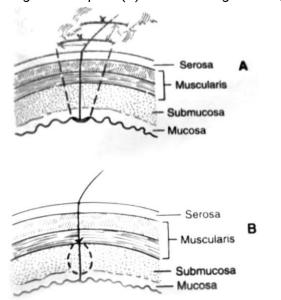


Perpendicular (Lembert)



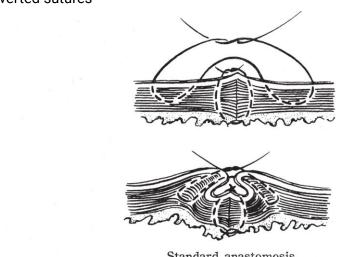
https://www.slideshare.net/drsatyajeetsingh/basic-suture-patterns

Single interrupted (A) and Crushing suture (B)

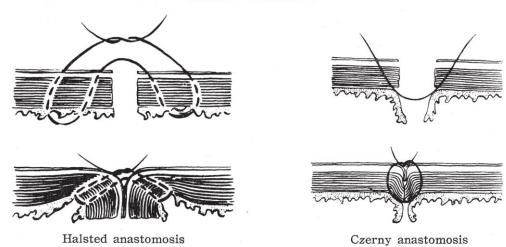


https://www.slideshare.net/drsatyajeetsingh/basic-suture-patterns

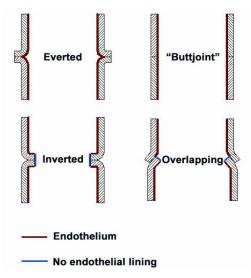
Inverted sutures



Standard anastomosis

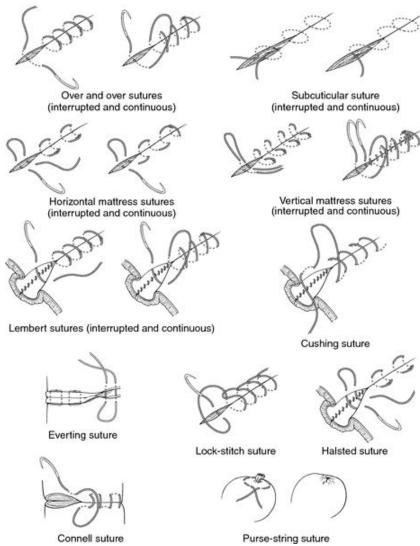


Halsted anastomosis FIG. 1. The three suture methods under investigation.



 $\frac{https://www.researchgate.net/figure/The-four-most-important-types-of-vessel-wall-apposition-Endoluminal-wall-not-lined-with_fig5_46698158$

Suturing techniques



https://www.pinterest.de/pin/161214861648258475/

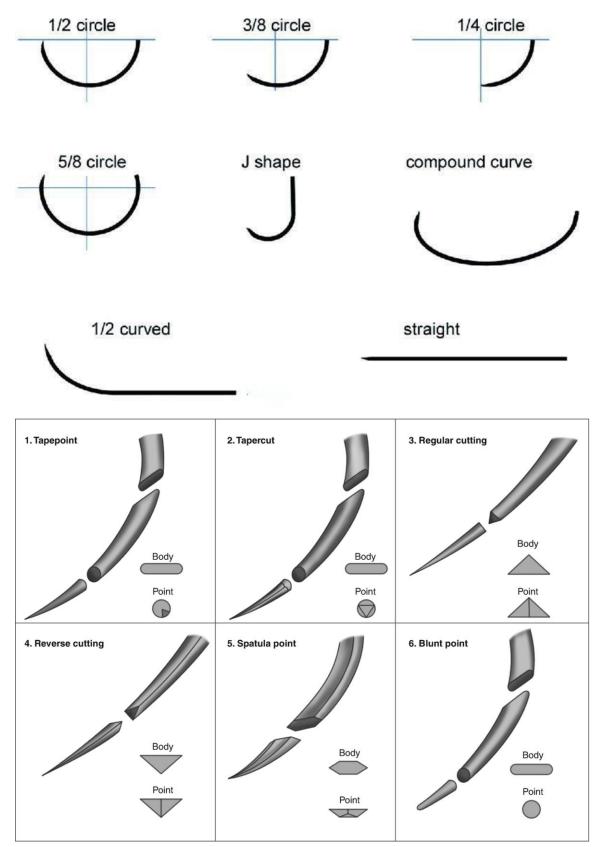
Appendix G: Suture thicknesses

Sizes in millimetres (mm)

U.S.P. Size	COLLAGEN	SUTURES	SYNTHETIC	SUTURES
	Metric Size	Diameter Range	Metric Size	Diameter Range
# 7	, - ,	π).	9	0.900 - 0.999
# 6	-	-	8	0.800 - 0.899
# 5	-	-	7	0.700 - 0.799
# 4	8	0.800 - 0.899	6	0.600 - 0.699
#3	7	0.700 - 0.799	6	0.600 - 0.699
# 2	6	0.600 - 0.699	5	0.500 - 0.599
#1	5	0.500 - 0.599	4	0.400 - 0.499
# 0	4	0.400 - 0.499	3.5	0.350 - 0.399
# 2-0	3.5	0.350 - 0.399	3	0.300 - 0.339
# 3-0	3	0.300 - 0.339	2	0.200 - 0.249
# 4-0	2	0.200 - 0.249	1.5	0.150 - 0.199
# 5-0	1.5	0.150 - 0.199	1	0.100 - 0.149
# 6-0	1	0.100 - 0.149	0.7	0.070 - 0.099
# 7-0	0.7	0.070 - 0.099	0.5	0.050 - 0.069
# 8-0	0.5	0.050 - 0.069	0.4	0.040 - 0.049
# 9-0	0.4	0.040 - 0.049	0.3	0.030 - 0.039
# 10-0	-	-	0.2	0.020 - 0.029

https://www.dolphinsutures.com/suture-sizes/

Appendix H: Needle shapes



https://link.springer.com/chapter/10.1007/978-3-319-91164-9_67

Appendix I: Themes

HANDLING OF NEEDLE

control over the needle

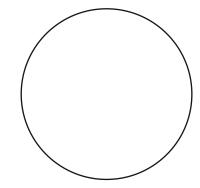
- needle is held more in the back (1/3)
- finding right position to penetrate the tissue
- finding the loop at the end of suture

placing needle into tissue

- controlling the direction of the stitch is difficult (should be perpendicular)
- tip of needle sometimes slips back and needs to be pushed through again
- it is easier when the needle goes from back to front (towards the surgeon)

transfer of needle from one instrument to another

- needle sometimes falls, needs to be picked up again
- the handing over from one tool to another is challenging

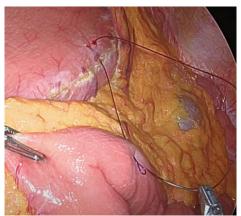


"Will it work out?"

"I struggle to find the loop"

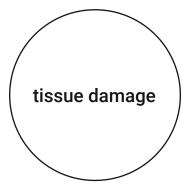


handing over the needle



needle through loop

ANASTOMOSIS QUALITY (HEALING)



- barbed suture might damage tissue
- too tight pulling of the suture might cause an enlargement of the stitch hole

connection of the tissue

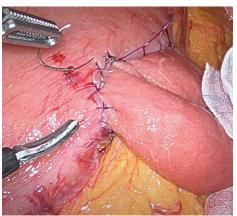
- tissue should be connected properly, alignment is not important
- end to end
- side to side
- side to end
- should not have too much tension
- inverted technique could cause stenosis and obstruction due to the inverted cuff, swelling or kinking

perfusion of the tissue

- for proper healing of the tissue, blood supply has to be guaranteed -> good vascularization
- pro-inflammatory substances and immune cells need to reach the wound

spacing between stitches/staples

 if there is too much spacing formation of a granulation tissue could be unsuccessfull



training boxes for laparoscopy

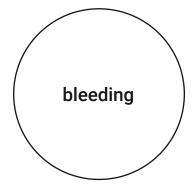


perfusion

"The ansastomosis should not be too tight but also not too loose"



PATIENT SAFETY



- hemorrhage might occur from staple lines or other causes
- if bleeding is too much, open surgery is needed

leakage

- getting a tight anastomosis is challenging
- leakage might occur and detected during or after the surgery
- extra suturing or follow up surgery might be needed
- surgeon can never be sure if its watertight

stricture

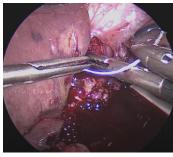
- stricture (narrowing) at the GI anastomosis
- · inner diameter has to be secured

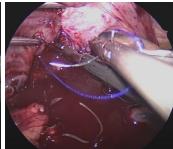
obsruction (blockage)

- caused by the inverted cuff, swelling, or kinking at the edge of the anastomosis









"What went

wrong?"

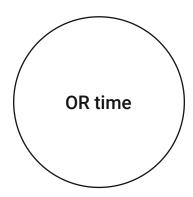
"How can I fix it?"



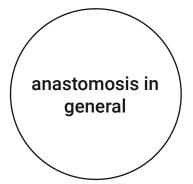
without leak with leak

laparoscopic bleeding

TIME & COSTS



- OR time is the most expensive factor
- the shorter the surgery the more cost effective (even if more expensive tools are used)
- goal is to have more operations a day (good for hospital and patients)



- time consuming
- for unexperienced surgeons it takes more time than for experienced ones
- this increases the surgery time
- refill of staplers takes time (linear staplers about 6x, hernia stapler about 2-3x), meanwhile surgeons have to wait



- practical training on training boxes helps to improve the skills, but it takes a lot of time to learn laparoscopic suturing
 - iaparoscopio (

waiting time for patients

- there are long waiting lists for patients
- for them it is a life saving surgery
- it would be beneficial to have more surgeries a day

"It takes many years to get experiened in laparoscopic suturing" "The longer it takes, the longer we need to stay here."



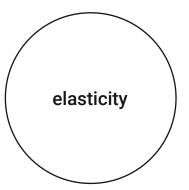
HANDLING OF TISSUE

handling

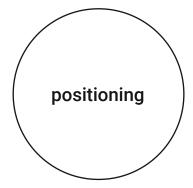
- tissue might slip through the grasper
- position tissue so its convenient to put needle through
- inverting the tissue is challenging

thickness

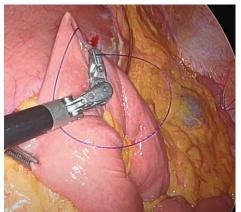
- getting the right amount of tissue is challenging
- this varies depending on the type of anastomoses



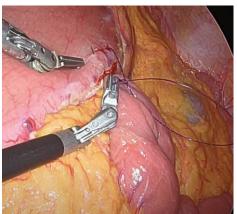
- tissue is elastic and might give way
- pushing needle through tissue takes some force



- inverted
- everted
- aligned



elasticity of the tissue

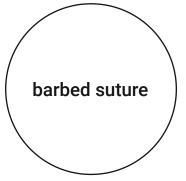


different tissue thicknesses

"It is annoying to have the tissue slip through the grasper" "Laparoscopy takes 4 to 6 times more force"



HANDLING OF SUTURE



- barbed sutures are easier to handle because no knotting is needed
- barbed suture can act as a saw and cause trauma
- when laying on the intestines, barbed suture hooks slightly in tissue surfaces
- the use of barbed sutures have been proven to be safe and effective

handling

- suture sometimes entangles itself, is in the way, especially when it is too long
- knotting is the most time consuming and challenging task

tighten the suture

- not tightening the suture after each stitch allows for having a shorter suture - easier to handle
- tightening a parallel stitch takes more force (more holes)
- overtightening knots

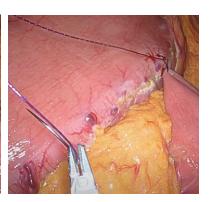
end the stitch

 end of suture (after cutting) should be short enough not to damage tissue



knot tying





tightening the stitch

" the shorter the suture the better"



SURGEON'S PERFORMANCE

hand suturing

 here most clumsiness happened (e.g. falling of needle) successfull anastomosis

- proud about accomplishment
- "See how beautiful"
- "Before it was a mess, now we have a great suture"

performance pressure

- team is expecting good performance
- shame when something goes wrong
- focus and tension

general skills

- motor skills
- visuospatial abilities
- medical knowledge

elasticity of the tissue



different tissue thicknesses

"Before it was a mess, now we have a great suture"

"See how beautiful?"



ACQUIRE SKILLS

learning

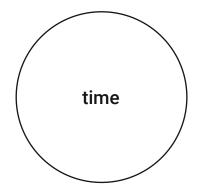
- it takes several years to learn laparoscopic suturing
- suturing it is a required skill to become a laparoscopic surgeon

teaching

- surgeon wants assistant to suture the way he wants
- explaining is difficult
- experienced surgeons expect residents to get the skills but acknowledge that it is difficult



- practical training can improve skills
- standardized training programs



- laparoscopic suturing takes significantly more time to learn than suturing in open surgery



"Why do you do it that way?"

"Yes! That's it, beautiful!"



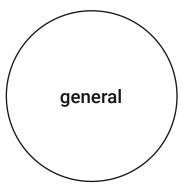
training boxes for laparoscopy

camera handling

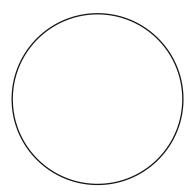
- camera is handled by the surgeon assistant, who might do unexpected movements/ not handle the camera properly
- surgeon cannot see if camera is not in the right position
- surgeon sometimes has to give instructions no direct control

handing over instruments

- from scrub nurse to surgeon
- without looking
- scrub nurse has to be always alert
- tools might fall on the ground
- scrub nurse forgets to reload stapler



- the longer the procedure takes the longer the team stays
- hands of surgeon, assistant, second assistant often overlap



- •
- •



camera is not positioned

"A good team is used to another's way of working"



scrub nurse handing over tools

ERGONOMICS

surgeon's body posture

- head in neck
- arms/shoulders high (due to long instruments)

tool interface

- surgeon needs to twist his arm and reach out to the back to grab a new tool
- handles are the only interface the surgeon is using
- research shows that handle design should be adaptable/ personizable -> this is still not reachable due to high costs



- fear of leakage
- suturing is a cognitive challenging task
- not many breaks
- pressure
- great concentration and mental stress



- shoulders and arms hurt from holding the long devices up
- force needed is higher than in open surgery
- standing all day is exhausting

.



"It is exhausting to stand all day and have the arms lifted up" "I want to shake my arms after the procedure."



scrub nurse handing over tools

camera is not positioned

ENVIRONMENTAL CONDITIONS

patient's condition (obesity, age)

- little space
- a lot of fat in the way
- · old, sick tissue

type of surgery

- location of the tissue
- type of tissue (e.g. stomach, small bowel)
- force to push through the tissue

conditon of the surgeon

- time of the day
- number of surgeries
- surgeon gets progressively more tired and less motivated (and more irritatable)
- only short breaks

laparoscopy related conditions

- no space to pull the suture
- if needed, different accesses are used to reach
- different angles
- 3D is displaced 2D (no depth perception)
- magnification of the anatomy

exhaustion of surgeon

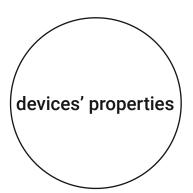
"If the patient is sick his tissue is more difficult to handle" "The shorter the suture the better to handle ."



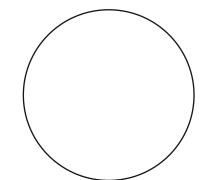
FAILURE OF DEVICES

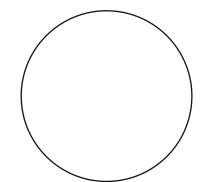


 "Why is the camera still not wireless? We can stir satellites and everything but cannot have wireless camera in the OR."



liver retractor might be too small due to obese patients

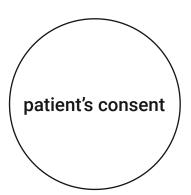




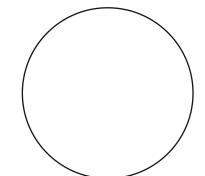
LEGAL ISSUES

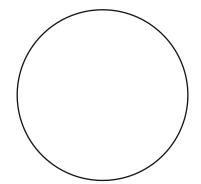


 barbered suture is not certified for the use in intestinal anastomoses



• to do other procedures





Appendix J: Suturing course





Appendix L: Concept evaluation

ost critical ues, critical risks	CRITERIA	workflow has little steps	steps are low in complexity (no potential for slips)	allows for flexibility in the application (stitch positioning)	method allows for different tissue thicknesses (from 2 to 5mm)	closure force is adaptable	attachment to the tissue is safe	tissue is in good contact (prevent leakage, support healing)	the solution does not cause tissue trauma	storage possibilities (cartridge, refill)	the way tissue is closed (appearance)	need for extra tool		
	WEIGHT	5	20	20	10	5	10	20	10	5	5	5	SUM	
	SCORE (1-10)	score, sum												
	Parallel stapler	9, 45	9, 180	10, 200	9, 90	10, 50	9, 90	10, 200	9, 90	6, 30	8, 40	4, 20	1035	
V	Tacks	7, 35	8, 160	10, 200	10, 100	10, 50	2, 20	5, 100	6, 60	10, 50	7, 35	7, 35	845	too risk
	Clamps	8, 40	6, 120	7, 140	3, 30	8, 40	3, 30	4, 80	3 30	5, 25	5, 25	5, 25	585	
	Clips	4, 20	7, 140	9, 180	7, 70	7, 35	9, 90	7, 140	9, 90	5, 25	5, 25	5, 25	840	
	Perpendicular stapler	4, 20	7, 140	9, 180	7, 70	8, 40	8, 80	8, 160	8, 80	5, 25	7, 35	5, 25	845	merge
1	Edge staples	8, 40	4, 80	9, 180	3, 30	7, 35	6, 60	6, 120	6, 60	8, 40	4, 20	5, 25	690	
k mater ealing, l	rials (influence powel stones, rable etc)		P2 might cause knowing whe punch)		max: clip	on 2 conce o and paralle tapler		P4 test with real	l intestine	positito	P5 e concept 2 b oning is diffic on to pull it	cult, no	3a and 3b intu most straightfo use	
ontact to epartmo	o pathology ent (PhD?), access to ne tissue	C	lip applier to	ool		real materia	nls m	nore iterations stapler (co		risk of 3a: so need t	loosing clip i 3b, ome hooks r o be bigger (3a and night (tissue	no trust in 2 (c	damage)
edicine (to internal department erdes, PhD?)		hould have i s (adjust pre			licular staple e flexible	er			recogni alread	ot 1 is favori zable for su y used, more easier to acc	rgeons, e trust	hooks of 3a do clip is very big leakage, diffi accompl	g, risk of icult to
(present	meetings ations for geons)				kick out	edge staple	s			positio (sur stapl	siest control ning, less m face), amour es is less; on ition cannot	aterial nt of ice in	no trust in cond 3a, most r	
aration (ask 0 and invo	nd invoices? form? online? Greetje) vices before				thicknesse	on different es of the tiss tissue prop				diffe slippe	tht be difficurent thicknessery material ause trouble	sses, could	in real tissu laparoscopic s might be di	etting, 2
					worksho	p/testing wit	th				econd favori		3b might be eas	iest in re

contact to Dirksland hospital surgeons (perhaps I can do a test on tissue in OR)



signature

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair _____ date __-

CHECK STUDY PROGRESS To be filled in by the SSC E&SA (Shared Service Center, Educ The study progress will be checked for a 2nd time just before	ation & Student Affairs), after approval of the project brief by the Chair. the green light meeting.
Master electives no. of EC accumulated in total: Of which, taking the conditional requirements into account, can be part of the exam programme List of electives obtained before the third semester without approval of the BoE	EC YES all 1st year master courses passed EC NO missing 1st year master courses are:
name date _	 signature
 Next, please assess, (dis)approve and sign this Project Brief, Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific 	se check the supervisory team and study the parts of the brief marked **. by using the criteria below. Content: APPROVED NOT APPROVED Procedure: APPROVED NOT APPROVED
 courses)? Is the level of the project challenging enough for a MSc IDE graduating student? Is the project expected to be doable within 100 working days/20 weeks? Does the composition of the supervisory team comply with the regulations and fit the assignment? 	comments
name date _	<u> </u>
IDE TU Delft - E&SA Department /// Graduation project brief Initials & Name Title of Project	Student number



Title of Project

	project title
Please state the title of your graduation project (above) and the st Do not use abbreviations. The remainder of this document allows	art date and end date (below). Keep the title compact and simple.
start date	end date
	n stakeholders (interests) within this context in a concise yet do they currently operate within the given context? What are the tural- and social norms, resources (time, money,), technology,).
space available for images / figures on next page	
IDE TU Delft - E&SA Department /// Graduation project brief & s	tudy overview /// 2018-01 v30 Page 3 of 7



Title of Project

ntroduction (continued): space for images	
image / figure 1:	
image / figure 2:	
DE TU Delft - E&SA Department /// Graduation project brief & study overview /// 2018-01 v30 Student number	Page 4 of 7



Title of Project

PROBLEM DEFINITION ** Limit and define the scope and solution space of your project to one that is ma EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(anageable within one Master Graduation Project of 30 s) should be addressed in this project.
ASSIGNMENT **	
State in 2 or 3 sentences what you are going to research, design, create and / out in "problem definition". Then illustrate this assignment by indicating what instance: a product, a product-service combination, a strategy illustrated throucase of a Specialisation and/or Annotation, make sure the assignment reflects	kind of solution you expect and / or aim to deliver, for ugh product or product-service combination ideas, In
IDE TU Delft - E&SA Department /// Graduation project brief & study overview	w /// 2018-01 v30 Page 5 of 7



		ΔPPR	

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities

start date			-	<u>-</u>	end date
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MOTIVATION AND PERSONAL AMBITIONS FINAL COMMENTS

IDE TU Delft - E&SA Department /// Graduation project brief & study overview	/// 2018-01 v30	Page 7 of 7
Initials & Name	Student number	
Title of Project		