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Mini Review

For they Know not What They do… Surgeons and Surgical Sutures

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ABSTRACT

Incisional Hernia (IH) formation is the complication in abdominal surgery most often requiring re-operation and has a considerable medical and socio-economic impact. Efforts to reduce IH incidence have mainly focused on suture material and suture technique in the last 50 years and have to be judged as ineffective. This review has its focus on the surgeon as an underestimated risk factor for IH formation and the effects of inadequate suture tension on the sutured tissue and the dynamics of suture tension. Surgeons are not able to control suture tension and tend to apply high suture tension when asked to repeatedly knot sutures with identical suture tension. High suture tension leads to a significant reduction of tissue perfusion of the abdominal wall in animal experiments and impaired tissue perfusion is a risk factor for IH formation. Fascial sutures in the abdominal wall show a spontaneous loss of suture tension of 50 % in vivo in animals under anesthesia for 24 hours and a complete loss of suture tension if an elevated intra-abdominal pressure is applied to simulate abdominal distension and muscular activity. Further research to solve the problem of IH formation has to focus on the surgeon with the aim to define a tissue-specific suture tension optimum. The complexity of the problems requires the cooperation of surgeons and technical engineers

INTRODUCTION

Surgeons are judged for what they do: Cutting, dissecting, reconstructing and suturing for the benefit of their patients. Although surgeons in general do not want to hear it: We are craftsmen, like watchmakers or blacksmiths and our skills are based on manual techniques combined with more and more subtle technology. In many fields of surgery, the progress made in the last 100 years is overwhelming. Thus male impotence after rectal cancer surgery was a criterion of a properly performed operation 100 years ago while today the laparoscopic, nerve sparing low anterior resection with total excision of the mesorectum is considered to be the gold standard. Surgeons have a tendency to bask in their success, forgetting about their limitations. In visceral surgery, opening the abdomen and laparotomy closure are considered as basic skills and closing the abdomen after an hour-long operation is often left to the unexperienced. We have to be aware, that the failure rate of abdominal closure with the development of either a ruptured abdomen or an incisional hernia is the post-operative complication most often requiring re-operation and runs up to a total of 20 %. The medical as well as the socio-economic effect of laparotomy closures failing is immense.

Imagine a new car series being sold nowadays with brakes failing in every fifth car and imagine the resulting storm of outrage in the public. We have to realize, that laparotomy closure failing in 20 % of cases is a chronic problem in surgery and this failure rate has remained unchanged in spite of a considerable scientific effort to modify suture materials and suture techniques during the last 50 years. Materials and techniques have been evaluated to such an extent that in 2010 Diner et al stated that `no further trials should be conducted for evaluation of technique and available materials for elective midline abdominal fascial closure, according to the results of our cumulative meta-analysis´.[1].

This critical review has only one aim:

To stimulate surgeons in union with technical engineers to focus on the unsolved problem of incisional hernias. It is hard to understand why surgeons are still reluctant to leave the beaten path when designing research projects with the aim to ameliorate the results of laparotomy closure. We present studies with a different approach that demonstrate surgeons´ disability to control suture tension, elucidate the effects of sutures in the abdominal wall and examine the dynamics of suture tension by microsensors in the abdominal wall after the sutures have been accomplished.

OUTLINING THE DILEMMA

The surgeon

When publishing articles or when discussing incisional hernia incidence and possible ways to solve this problem on surgical conferences and conventions, contributions that put surgical skills into question are rare and not very welcome.

Surgeons claim that they possess a partly learned and partly gifted feeling and sensitivity for what tissue `needs´ in form of suture tension. This self-confidence is unfounded. One of our studies with a digital `knot-trainer´ aimed at evaluating surgeons´ capability to repetitively knot sutures so that the resulting loops had the same suture tension, thus testing reproducibility and precision. We also evaluated if it is easier for surgeons to reproduce suture tension at levels they individually consider as low, adequate and high for the closure of abdominal fascias. The results were astonishing: What surgeons consider as `adequate´ suture tension for fascial closure shows a significant inter-individual variability. Intra-individual precision (task: repetitious sutures with identical suture tension) is low and it seems to be most difficult for surgeons to repetitiously knot with low tension. Precision is highest, when high suture tension is applied [2]. If we postulate the existence of an `ideal suture tension´ that allows undisturbed fascial healing, then surgeons are not able to control it. The `surgical feeling´ for what the tissues needs in terms of suture tension is a myth.

Abdominal wall tissue perfusion

Surgical sutures have one central task: Keeping sutured tissues approximated long enough to allow the formation of sufficiently stable regenerative tissue during the process of wound healing. When examining cross-sections of the abdominal wall after laparotomy closure microscopically, we found that sutures do not remain in their primary position to both sides of the incision but they move towards the incision to an extent that depends on the applied suture tension. Suture cut through the tissue leaving behind a tail of necrotic tissue and compress the sutured tissue in front of them forming an area of necrotic tissue between the suture and the incision. Due to the resemblance to a comet, we called the phenomenon `comet-tail-phenomenon´. The motion of the suture through the sutured tissue is a result of tissue strangulation. Sufficient blood supply is a prerequisite for undisturbed wound healing and strangulation leads to impaired tissue perfusion. To get an insight into the immediate effects of fascial closure on tissue perfusion of the abdominal wall, dynamic laser fluorescence angiography was performed in vivo in rabbits after closure of median laparotomies with evaluation of qualitative and quantitative influence of different suture tension levels. A marked and statistically significant change of abdominal wall perfusion was registered when fascial sutures were applied with high suture tension compared to low suture tension levels [3].

The dynamics of suture tension

The `comet´s tail phenomenon´ was a hint that sutures become part of a highly dynamic structure and that the interface between tissue und sutures deserves a closure look. Due to the lack of adequate measurement devices, we developed miniaturized sensors that allow the measurement of suture tension dynamics in vivo online on the thread after completion of fascial closure. This pioneer development was achieved together with the engineers from the Fraunhofer Institute for

Production Technology (IPT) in Aachen, Germany. The results of animal experiments were impressive. In pigs with a mean weight of 50 kg and continuous closure of midline laparotomies which remained under anesthesia for 24 hours without further interventions, the initial mean suture tension required to achieve fascial closure reduced spontaneously to 55 % of initial tension after 24 hours with the steepest loss of tension (-26 %) only one hour after completion of laparotomy closure. In the `intervention group´ of this experiment, intervals of elevated intraabdominal pressure were applied to simulate muscular activity and abdominal distension. In this group the loss of suture tension was 80 % after 9 hours and merely total after two intervals of elevated intra-abdominal pressure [4,5].

CONCLUSION AND OUTLOOK

1. If surgeons are not able to control suture tension manually, we have to accept that we are a central risk factor when it comes to the failure of abdominal wall closure.
2. When our precision to reproduce sutures with a certain tension is best when we apply high suture tension and if we accept that inadequately high suture tension is a risk factor for acute wound failure and incisional hernia formation, then manual control of suture tension is not enough to fulfil quality requirements medicine in the 21st century.
3. If suture tension reduces spontaneously by half 24 hours after closure of a median laparotomy in an animal without relevant muscular activity and almost totally when muscular activity and distension of the abdominal cavity are simulated, we have to query all theories about sutures and surgical suture technique: Sutures reduce inadequate tension by cutting through the tissue. This regulation leads to an `auto-adjustment´ of suture tension at the cost of tissue necrosis and with the risk of acute wound failure. If we were able to define a tissue specific suture tension optimum by further research, there would be no need for auto adjustment of suture tension and tissue strangulation and necrosis could be reduced for the sake of less ruptured abdomens and incisional hernias.

We would like to encourage surgeons and surgical researchers together with mechanical engineers to engage into research projects that help to reduce the complication in abdominal surgery most often leading to re-interventions. As described, the problem is complex and it might be the unconventional approach that leads us to success. We have tried to keep the message of this article plain and simple: Look ahead and leave the beaten path. We have reduced the cited literature to a minimum not because we did not study the literature but to get rid of redundancy and ballast. In the year 2000 van Geldere wrote: `One hundred years of abdominal wound dehiscence and nothing has changed´[6]. Another 21 years have passed since the publication of this article and still no achievements have been made – a further standstill cannot be accepted.

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