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Surgery for Obesity and Related Diseases ▮ (2017) 00–00

SURGERY FOR OBESITY AND RELATED DISEASES

Original article

Improving the side-to-side stapled anastomosis: comparison of staplers for robust crotch formation

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Received August 4, 2017; accepted September 26, 2017

Abstract

Background: Few studies have investigated the burst pressure of side-to-side anastomoses comparing different stapling devices that are commercially available.

Objectives: We conducted side-to-side anastomoses with a variety of staplers and compared burst pressure in the crotch of the anastomoses.

Setting: Nagoya City East Medical Center.

Methods: We conducted side-to-side anastomoses with 9 staplers with different shapes and forms. Fresh pig small intestines were used. A side-to-side anastomosis was performed between 2 intestine specimens using a linear stapler. The burst pressure of the anastomosis was recorded.

Results: In total, 45 staplers were used for this experiment. The site of leakage in all cases was the crotch. Regarding the influence of the number of staple rows, the burst pressure in 3-row staplers was significantly higher than in 2-row staplers. With regard to the relationship between staple height and burst pressure, staples with a height slightly shorter than the intestinal thickness showed the highest burst pressure. In a comparison of staplers with uniform staple heights and stamplers with staples of 3 different heights, the latter had significantly lower burst pressures. Neoveil significantly increased the burst pressure in the crotch and contributed to the highest burst pressure of all the staplers used in this experiment.

Conclusions: In this experiment, we defined the important factors that influence burst pressure at the crotch of a stapled, side-to-side anastomosis. These factors include the number of staple rows, the height of the staple compared with the thickness of the tissue, uniformity of staple height, and reinforcement of the staple line. In any surgical case requiring intestinal anastomosis, selection of a stapler is a critical step. (Surg Obes Relat Dis 2017;▮:00–00.) © 2017 American Society for Metabolic and Bariatric Surgery. All rights reserved.

Keywords: Side-to-side anastomosis; Crotch; Pressure resistance; Stapler

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As part of the recent, rapid technologic development in surgery, various automatic suture instruments have been produced to create safe, secure anastomoses. The growth of laparoscopic surgery has further accelerated the frequency of the use of such staplers. Staplers themselves have been improved drastically in terms of form and function [1]. In gastrointestinal surgery, linear staplers are thinner, have increased suture strength, and can be used for anastomoses between various gastrointestinal tissues. Circular stapler use has decreased, and it has been largely supplanted by the

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http://dx.doi.org/10.1016/j.soard.2017.09.532
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side-to-side anastomosis using the linear stapler [2]. The disadvantage of the side-to-side anastomosis is the formation of a crotch, which is an inherent point of weakness compared with the longitudinal portion of the anastomosis [3]. Depending on the location of the sutured intestinal tract, the crotch may be sutured and reinforced manually; however, this cannot be done in all situations. In cases where reinforcement is impossible, a stapler should be selected to confer higher burst pressure to the crotch. Hence, we conducted side-to-side anastomoses with various staplers available on the market and compared the burst pressure of the crotch.

Methods

In this experiment, we analyzed the burst pressures of anastomoses using 9 different staplers. Fresh small intestine of a pig weighing 100 to 120 kg were used. The specimens were obtained from an animal that had been killed for use in approved nongastrointestinal research studies. The specimens were used within 24 hours after death. Each segment of intestinal tract was 20 cm in length.

A side-to-side anastomosis was performed between 2 intestine specimens using a linear stapler. The stapler was inserted from the edge of each segment of intestinal tract. A 16-Fr catheter was then place into the lumen through one intestinal wall. Each side of the anastomosis was clamped with forceps. A sphygmomanometer and tubing for insufflation was connected, and the anastomosis was submerged in water. Air was then blown into the intestinal lumen with a syringe.

The burst pressure of the anastomosis was measured upon first presence of bubbles in the water. All procedures were performed by the same surgeon.

Stapling devices

A total of 6 different staplers were used. In addition, Echelon Stapler Reloads White reinforced with Neoveil (GUNZE) was used. To verify the effectiveness for the pressure resistance by converging the suture line in a natural way toward the center of the crotch, 2 staples (top/outer) of Echelon Stapler Reloads White were removed (named –R). As a result, 9 different total shapes and forms were compared (Table 1). Five staplings were performed per stapler. The staplers used were: Linear Cutter White (Ethicon, Tokyo, Japan); Endo GIA Reload with Tri-Staple cartridges (EGIA-AVM; Medtronic, Tokyo, Japan); and Echelon Stapler Reloads Gray/White/Blue/Gold (ECHE-M/W/B/D; Ethicon).

This study was an independent study with no industry funding.

Statistical analysis

Discrete variables were analyzed by the Mann-Whitney U test and significance was indicated at $P < .05$.

Results

The thickness of pig small intestine was 1.24 ± .15 mm. In total, 45 staplings were performed, and leakage occurred at the crotch in all cases. The mean burst pressure for each stapler is shown in Table 2 and Figs. 1 and 2.

Mean burst pressures in 2- versus 3-row staplers with the same staple height were 36 ± 3.8 versus 59.3 ± 2.4 mm Hg. This was statistically significant ($P < .01$). When comparing the influence of removal of the top staple, burst pressure was higher with a normal stapler (EGIA-AVM versus EGIA-AVM-R, ECHE-W versus EC HE–W-R). The EGIA-AVM stapler confirmed a significant difference.

Table 1
Specifications of staples

	Open staple height, mm	Closed staple height, mm	Rows of staples	Number of staples at the tip	Array of staples at the tip of the cartridge
TLC-W	2.5	1	2	2	
EGIA-AVM	2/2.5/3	0.75/1/1.25	3	4	
ECHE-M	2	0.75	3	4	
ECHE-W	2.5	1	3	4	
ECHE-B	3.5	1.5	3	4	
ECHE-D	3.8	1.8	3	4	
ECHE-W+Neo	2.5	1	3	4	
EGIA-AVM-R	2/2.5/3	0.75/1/1.25	3	2	
ECRW-R	2.5	1	3	2	

TLC-W = Linear Cutter White; EGIA-AVM = Endo GIA AVM; ECHE-M/W/B/D = Echelon Stapler Reloads Gray/White/Blue/Gold; Neo = Neoveil; R = staples (top/outer) were removed.
The dotted line represents the cut line.

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