Physiological Study of Anal Sphincteric Resection in an Experimental Porcine Model

YUICHIRO SATO, YASUMI ARAKI*, YUTAKA OGATA
AND KAZUO SHIROUZU

Department of Surgery, Kurume University School of Medicine, Kurume 830-0011
and *Kurume Coloproctology Center, Kurume 839-0865, Japan

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Summary: This study was conducted to compare and evaluate the extent of anal sphincteric resection and the degree of anal dysfunction in sphincter saving operations for lower rectal cancer using experimental porcine models. Each 10 Clown miniature pigs underwent transanal intersphincteric resection (ISR), ISR with partial (one-quarter) external sphincteric resection (ESR-25%), and ISR with partial (one-half) external sphincteric resection (ESR-50%). An anorectal physiological study was performed before, one month, and three months after surgery in these three groups. The anal maximum resting pressure (AMRP) decreased from 45.1 cmH₂O in the control group to 14.8, 14.3 and 11.1 cmH₂O one month after surgery, and to 15.2, 8.8 and 5.2 cmH₂O three months after surgery, in the ISR, ESR-25% and ESR-50% groups, respectively. The anal maximum squeezing pressure (AMSP) decreased from 81.7 cmH₂O in the control group to 42.1, 40.1 and 41.1 cmH₂O one month after surgery in the ISR, ESR-25% and ESR-50% groups, respectively. Three months after surgery, the MSP increased to 78.1 and 68.1 cmH₂O in the ISR and ESR-25% groups, respectively, but the ESR-50% group showed a significantly lower MSP of 39.2 cmH₂O compared with other two groups. The ratio of the potential difference on electromyographic (EMG) was 0.19 in the ESR-50% group, and this value was significantly lower than 0.8 in the ISR and ESR-25% groups, one month after surgery. Three months after surgery, the potential ratio of EMG was increased almost to the preoperative level both in the ISR and ESR-25% groups, but the ratio of the potential difference in the ESR-50% group with redness, sore and soiling around anus was 0.19 and significantly lower compared with other groups. The results of this study indicate that porcine models with additional resection of less than one quarter of the external anal sphincter have little anal dysfunction. A human clinical trial is needed to determine the ESR for very low rectal cancer.

Key words intersphincteric resection (ISR), external sphincteric resection (ESR)

INTRODUCTION

Surgical treatment for low rectal cancer is shifting from resection with colostomy to sphincter saving operation without colostomy because the latter procedure does not affect postoperative local recurrence adversely compared with abdominoperineal resection (APR) [1] and also because dyschezia is not severe postoperatively [2]. Since Schiessel et al. [2] reported intersphincteric resection (ISR), with excision of the internal anal sphincter and preservation of the anus, for low rectal cancer close to the anus, oncologic and functional studies of this surgical technique have been performed [3-6]. Recently, a surgical technique...
involving partial resection of the external anal sphincter also has been reported [7].

However, the evaluation results on the relation between extent of anal sphincter resection and the degree of anal dysfunction differ from one researcher to another. The aim of this study is to compare and evaluate the extent of internal and external sphincteric resection and the degree of anal dysfunction using experimental porcine model.

MATERIALS AND METHODS

Preparation of ISR and ESR models

Three-month-old Clown miniature pigs weighing 25 kg were immobilized with 25 mg/kg ketamine hydrochloride (Ketalar) and generally anesthetized by intravenous injection of 25 mg/kg pentobarbital sodium (Nembutal). The animals were divided into three groups. In the complete intersphincteric resection group (ISR group) (Fig. 1a), about 3 cm of the anal canal was excised through a circumferential incision into the intersphincter transanally from the intersphincteric groove between the internal and external anal sphincters, with subsequent transanal anorectal anastomosis. A second group underwent resection of the left anterior quarter of the superficial and deep external sphincters, with complete ISR, and served as 25% external sphincteric resection group (ESR-25% group). The third group underwent resection of one half of the superficial and deep external sphincters, with complete ISR, served as the 50% external sphincteric resection group (ESR-50% group) (Fig. 1b).

Anorectal motor functional study

According to St. Mark’s technique [8,9], the rectal pressure (RP), anal high pressure zone (AHPZ) and anal maximum resting pressure (AMRP) were measured under general anesthesia preserving spontaneous breathing with a polygraph system LEG-1000 (NIHON KOHDEN CO, Tokyo, Japan). To measure the anal maximum squeezing pressure (AMSP) and electromyographic (EMG) activity of the external anal sphincter, electrical stimuli were given transanally using Stimulator/Isolator. A concentric needle was inserted to the external anal sphincter with a depth of approximately 1 cm, and the EMG waveform was recorded using Neuropack micro MEB-9100 evoked potential/EMG measuring system (NIHON KOHDEN CO, Tokyo, Japan). The finger, containing the stimulating electrode in the tip, was introduced until stab-
lishing contact with the ischial spine, while the recording electrode, in the base of the finger remained in contact with the sphincter. A stimulus intensity of 5-12 mA was used for the test. The optimal stimulation potential was applied to induce contractions (Fig. 2). Measured data were evaluated by comparing the optimal stimulation potential one and three months after surgery to the preoperative level.

**Incontinence score**

Pigs have the habit of defecating in one area of the cage, but animals with anal damage show an abnormal behavior of defecating in several areas. Therefore, incontinence score was evaluated by scoring the areas of defecation as an objective symptom and soiling and perineal dermatitis from 0 to 3 (Table 1). All pigs used for this investigation was treated in accordance with the National Institutes of Health’s Guide for the Care and Use of Laboratory Animals.

**Statistical analysis**

Data were given as mean (standard deviation). Differences between groups were tested using the unpaired t-test and the chi-squared test of Fischer’s exact test when appropriate. A value of \( P < 0.05 \) was considered statistically significant.

**RESULTS**

The AMRP decreased from 45.1 cmH\(_2\)O in the control group to 14.8, 14.3 and 11.1 cmH\(_2\)O one month after surgery, and to 15.2, 8.8 and 5.2 cmH\(_2\)O three months after surgery, in the ISR, ESR-25% and ESR-50% groups, respectively. The AMSP decreased from 81.7 cmH\(_2\)O in the control group to 42.1, 40.1 and 41.1 cmH\(_2\)O in the ISR, ESR-25% and ESR-50% groups, respectively, one month after surgery. The AMSP increased to 78.1 and 68.1 cmH\(_2\)O in the ISR and ESR-25% groups, respectively, but significantly decreased to 39.2 cmH\(_2\)O in the ESR-50% group three months after surgery (Fig. 3).

The ratio of the potential difference on EMG was 0.19 in the ESR-50% group, and this value was significantly lower than 0.8 in the ISR and ESR-25% groups, one month after surgery. Three months after surgery, the potential ratio of EMG was increased almost to the preoperative level both in the ISR and ESR-25% groups, but the ratio of the potential difference in the ESR-50% group was 0.19 and significantly lower compared with other groups (Fig. 4).

In incontinence score three months after surgery, the ISR and ESR-25% groups had no abnormalities in objective findings of the anus, but the ESR-50% group showed redness, sore and soiling around the anus, and had significantly poorer incontinence score (Fig. 5).

**TABLE 1. Incontinence score**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perineal dermatitis</td>
<td>none</td>
<td>redness</td>
<td>erosion ulcer</td>
</tr>
<tr>
<td>Soiling</td>
<td>none</td>
<td>sometimes</td>
<td>always</td>
</tr>
<tr>
<td>Stool in the rectum</td>
<td>none</td>
<td>sometimes</td>
<td>always</td>
</tr>
<tr>
<td>Frequency of defecation / day</td>
<td>1</td>
<td>2-3</td>
<td>3&lt;</td>
</tr>
</tbody>
</table>

**Fig. 3.** Profile of pre-and post-operative manometric study.
Parks [10], retrospectively studied the patients with APR and reported that, owing to mechanical anastomosis and transanal anastomosis for lower rectum, a sphincter saving operation was oncologically possible in 20% of patients. Since Schiessel et al. [2], reported ISR, which consists of resection of the internal anal sphincter and preservation of the anus, for low rectal cancer close to the anus, oncologic and functional studies of this surgical procedure have been performed [3-6,11].

Some authors recommended ISR only for early staged tumors [12], whereas others included more advanced disease by use of neoadjuvant treatment [6,13,14]. Oncologic results showed local recurrence rates of 0 to 13% [2,6,13,15-18]. Contraindications are infiltration of the external anal sphincter and fixed tumors (T4), although ISR has been proposed in very selected cases with fixation on levator ani muscles [19].

There was no difference in stool frequency, fragmentation, urgency, dyschezia or alimentary restriction between patients with ISR and those with conventional coloanal anastomosis for very low rectal cancer [11].

Clinical studies demonstrated that the AMRP decreased by 38% after total ISR [2,4]. The AMRP decreased similarly by 34% in the present study using experimental models. If partial resection of the external anal sphincter is possible, ISR can be oncologically indicated for more patients. We therefore planned this experimental study to investigate the postoperative anal dysfunction after partial resection of the external anal sphincter.

Pigs have the habit of defecating in one area of the cage, but animals with anal damage show an abnormal behavior of defecating in several areas. Animals in the ISR and ESR-25% groups defecated normally in one area, but those in the ESR-50% group defecated in several areas and had severe anal dysfunction with persistant soiling and soreness around the anus. The degree of anal dysfunction after ISR with resection of one quarter of the superficial external sphincter is similar to that of the postoperative dysfunction after ISR.

The data on anal function in porcine subjects receiving ISR with 25% ESR were similar to those in animal models receiving ISR. As anal function as well as the remaining colon function and fecal quality are involved in the postoperative dyschezia, the results of this experimental study may not be immediate clinical implications, but our findings suggested a possibility of partially resecting the external anal sphincter in respect of preserving anal function.

CONCLUSION

Our study suggested that subjects with one quarter or less of the external sphincter resected have little anal dysfunction. A human clinical trial will be needed to determine the usefulness of ESR in very low rectal cancer.

REFERENCES

42:1160-1167.


