Original Article

Sequential Silo Placement and Relaxing Skin Incision for Complex Gastroschisis

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Background: Complex gastroschisis is an anterior abdominal wall defect associated with gastrointestinal anomalies or liver herniation. Operative repair of complex gastroschisis can be challenging. The authors described a technique of staged repair to achieve rapid and gentle reduction of the herniated contents, followed by delayed closure of the abdominal wall defect.

Objective: To describe the experience with the sequential silo placement (SSP) and relaxing skin incision (RSI) in complex gastroschisis patients.

Materials and Methods: A retrospective study of patients with complex gasroschisis treated by SSP and RSI at Queen Sirikit National Institute of Child Health between January 2013 and December 2017 was conducted. SSP included placement of the Alexis wound retractor and protector first and followed by placement of the Steri-drape artificial sac later. RSI included a curvilinear skin incision on lateral abdominal wall to achieved abdominal wall closure. Patients were followed for complications and outcomes.

Results: Six patients with complex gastroschisis, two with ileal atresia, three with colonic atresia, and one with liver herniation were enrolled in the present study. Five patients with intestinal atresia underwent second silo placement and enterostomy, three of these patients achieved abdominal wall closure without RSI, and two achieved abdominal wall closure by RSI. One patient with liver protrusion underwent SSP and achieved abdominal wall closure by bilateral RSI. Synthetic absorbable meshes were used for closure of fascial defect in five patients without post-operative adhesion or fistula formation. There was ventral hernia in one patient, which was repaired two years later without complication.

Conclusion: SSP and RSI are very simple and useful technique to repair complex gastroschisis with large abdominal wall defect and severe viscera abdominal disproportion.

Keywords: Sequential silo placement, Relaxing skin incision, Complex gastroschisis, Staged repair, Gastroschisis

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Gastroschisis is the most common congenital abdominal wall defect. The prevalence is increasing throughout the world[1-3]. Although published rates of survival are typically between 90% and 100%[4,5], some babies experience significant mortality, primarily from prolonged gastrointestinal dysfunction or loss of adequate abdominal wall component. The present study's experience, like others, suggests that gastroschisis patients could be divided into two groups, simple gastroschisis that occurs as an isolated defect and complex gastroschisis that is associated with other gastrointestinal anomalies such as intestinal atresia, perforation, necrosis, volvulus[6,7], and liver protrusion.

Complex gastroschisis affects 11% to 31% of gastroschisis patients[7,8]. The challenging problems in management of these patients are the quantity of operations, delayed in achieving full enteral feeding, increased incidence of prolonged paralytic ileus, longer average hospital stays, and higher mortality rates[6,8].

Most retrospective reports in the surgical literature that deal with patients with complex gastroschisis, have concentrated on the controversies surrounding the optimal surgical approach to these patients such as type of abdominal wall closure[10] and timing for intestinal continuity[11]. There is no consensus

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indicating which repair technique is superior. Additionally, protocols for the management of these patients are absent in current medical literature.

The authors reported the successful surgical management utilizing sequential silo placement (SSP) and relaxing skin incision (RSI) techniques in complex gastroschisis patients.

Materials and Methods

Study design

After obtaining approval from the Institutional Research Ethics Committee, a retrospective review was performed of all patients with complex gastroschisis treated by staged closure with SSP and RSI at Queen Sirikit National Institute of Child Health (QSNICH) between January 2013 and December 2017. Demographic data, intestinal complication prior to surgery, and comorbidities were reviewed. Operative details including specifics of the silo, use of mesh, and specifics of abdominal wall closure techniques were reviewed. The details of the post-operative course were also reviewed, including post-operative day of extubation, time to first feeding, time to full feeding, length of hospital stays (LOS), and complications. Patients outcomes were followed up during the study period.

Sequnetial silo placement technique

After the patients were hemodynamically stable, the procedure began by placement of the Alexis wound retractor and protector (AWR). Alexis® wound retractor and protector device (Applied Medical Resources Corp., USA) is a commercial wound retractor and protector system, made with polyurethane used for open laparotomy and hand-assisted laparoscopic surgery to protect the wound and considered to be low reactivity to human tissue[12]. The AWR consisted of two rings, an elastic white one and elastic green one, a transparent rubber cylinder connects the two rings. This device is available in different diameters. The authors used the sizes XS with the ring diameter of 4 cm. At the bedside under aseptic precaution, the AWR placement was performed. The herniated viscera was inserted into the retractor through the green ring, and then the bottom ring was placed into the peritoneal cavity through the gastroschisis defect without suturing to the fascia defect. Adhesion from the fascia to the bowel wall was gently disrupted manually. In the case of small abdominal wall defect or huge eviscerated content which may caused morbidity to the content if placement was performed at bedside, the AWR placements were performed in the operating room under general anesthesia[13]. The AWR was gradually reduced daily until maximum reduction and could not progress due to swollen intestine or liver herniation. If the reduction was continued, the AWR would dislodge from the defect.

After that, the patients underwent steri-drape artificial sac (SAS) placement in the operating room under general anesthesia. A SAS used at QSNICH was described by Havanonda et al[14]. It is made of a stockinette pouch, which is lined both inside and outside with steri-drape (3M Health Care, USA). First, the AWR was removed and the abdominal wall defect was extended upwards and downwards 2 to 3 cm to prevent obstruction during bowel reduction. The SAS was placed to cover over the herniated viscera and the defect. Continuous suturing was approximated between the SAS and all layers of the abdominal defect by non-absorbable sutures (2-0 nylon). The upper limit of the SAS was closed with a simple tie with umbilical tape, and the base was covered with gauze soaked in povidone iodine solution.

In cases of intestinal complications such as intestinal atresia or intestinal perforation, enterostomy was performed at the proximal end of the atretic part or the perforated site. The SAS was given bedside gradual reduction daily, the upper part of the SAS was clamped by plastic clip in vertical direction to reduce the diameter of the defect. After complete reduction or the content could not be reduced anymore due to viscera abdominal disproportion (VAD), the patients underwent abdominal wall closure.

Abdominal wall closure with relaxing skin incision procedure

After the SAS was removed, abdominal wall closure was performed. First, the eviscerated contents were inspected and checked for viability. The abdominal wall was stretched to create the maximum capacity of the intraabdominal cavity. The sheath and abdominal walls were dissected to separate each layer. Reduction of the SAS in vertical direction would shape the fascial defect in rectangle shape, which had shorter diameter than traditional SAS reduction[14]. In case of inadequate fascial tissue to complete fascial closure, underlaying polyglactin mesh (Vicryl mesh) was used to support the fascial defect. Two-O polyglactin suture (Vicryl) was parachute-sutured the mesh in place. The knots for mesh were placed superficial to rectus sheath.

The skin was estimated for complete abdominal wall closure. In case of inadequate skin to complete

abdominal wall closure, the RSI procedure was performed. The 6 to 8 cm curvilinear skin incision was performed at the lateral aspect of the abdominal wall, which was free from enterostomy. The skin and sub-cuticular layer were dissected to achieved adequate tissue for abdominal wall closure. In case of inadequate skin for closure due to huge abdominal wall defect, the second RSIs was performed at the contralateral site (Figure 1). In case of intestinal atresia with enterostomy, the second RSI was performed medial to the enterostomy. The RSI wounds were wet dressed until granulation tissue grew and the wounds were secondarily healed without suturing.

Ethical approval

This study was approved by the Research Ethics Review Committee of Queen Sirikit National Institute of Child Health No.REC.013/2562 (Full Board). Date of approval: October 17, 2018.

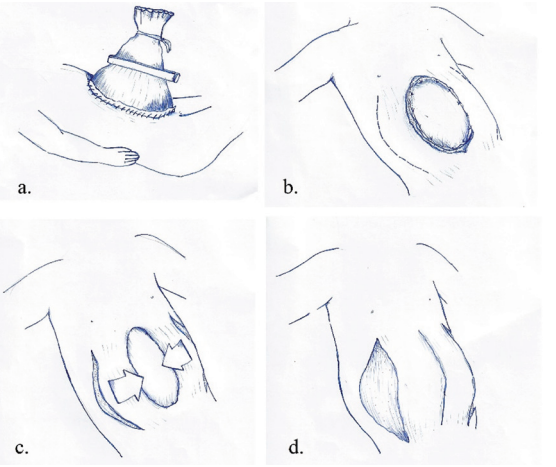

Figure 1. Abdominal wall closure with SSP and RSI. (a) SAS reduction in vertical direction, (b) Inadequate fascial and skin closure, (c) Relaxing curvilinear skin incision, (d) Complete abdominal wall closure.

Results

Of the 217 patients of gastroschisis, 23 (10.59%) were classified as complex gastroschisis, which three had intestinal perforation, 18 had intestinal atresia, four had closed gastroschisis, and one patients of liver herniation. One patient could have more than one complication (Figure 2).

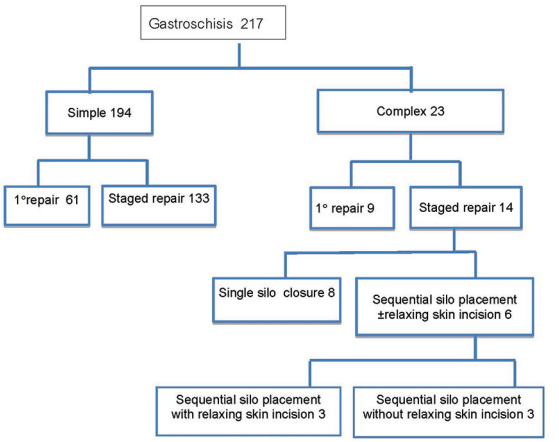

Figure 2. Management of gastroschisis patients. Of 217 patients of gastroschisis, 23 were classified as complex gastroschisis, 3 patients underwent SSI without RSI, and 3 patients underwent SSP and RSI.

Nine patients of complex gastroschisis had primary abdominal wall closure with primary bowel anastomosis or enterostomy and delayed bowel anastomosis. In fourteen patients, the defects were too large for primary fascial closure, underwent staged repair, eight of these underwent silo placement at the first day of life and underwent fascial closure later, and six cases that had severe VAD underwent SSP. Figure 2 summarize the management of gastroschisis patients. Gestation and birth weight were not significantly different from those staged repairs with single silo placement and SSP, as shown in Table 1.

Demographic data and surgical procedure of six patients with severe VAD are summarized in Table 2. Of the two patients with ileal atresia (patients 1 and 2), they had SSP with enterostomy and secondary abdominal wall closure at 17 to 22 days. Patient 3 with colonic atresia also had SSP with enterostomy and secondary abdominal wall closure with mesh on the thirty-first day. Patients 4 and 5 with very dilated colonic atresia and severe VAD had SSP with enterostomy and secondary abdominal wall closure with mesh and RSI at 24 to 30 days. Patient 6 with liver herniation and severe VAD had SSP and secondary abdominal wall closure with mesh and bilateral RSI on the 34 days. The median age of abdominal wall closure was 27.5 days (17 to 34 days). Initial enteral feeding was established in abdominal closure without RSI by 10 to 18 days post-operatively and in abdominal closure with RSI by 21 to 25 days post-operatively. Length of stay for abdominal closure without RSI was 45 to 62 days, and for abdominal closure with RSI was 78 to 88 days. Five patients with enterostomy underwent closure of enterostomy at mean 207 days (181 to 255 days) of age.

The most common post-operative complication was prolonged paralytic ileus in four cases, partial

Table 1. Gestation, birth weight, and anomalies of complex gastroschisis patients with staged repair (n=14)

	Single silo closure (n=8)	Sequential silo placement with or without RSI (n=6)	p-value
Gestational age (weeks), Mean±SD	38.88±2.74	35.50±1.97	0.738
Range	31 to 40	33 to 37	
Birth weight (g), Mean±SD	2,402.50±687.07	2,455.83±465.40	0.734
Range	1,585 to 3,800	1,900 to 3,070	
Intestinal complication, n			
Ileal atresia	4	2	
Colonic atresia	4	3	
Liver herniation, n	0	1	
Length of stay (days), Mean±SD	115.75±67.05	67.50±17.79	<0.001
Range	37 to 192	45 to 88	

SD=standard deviation

parenteral nutrition (PPN) induced cholestatic jaundice in two cases and ventilator associated pneumonia in two cases. All patients got full oral feeding before discharge. None of the patients died and the median age of follow-up was 13.5 months (9 to 36 months). Case No.6 with liver herniation had ventral hernia, underwent repair of ventral hernia at 31 months of age with uneventful post-operative cause.

Discussion

The presence of complex gastroschisis is the factor that predict poorer outcomes of this anomaly[1]. The prevalence of complex gastroschisis in recent publications has been reported as 11% to 31%[2,5-8]. The present study reported the presence of complex gastroschisis in 10.59% of patients with gastroschisis.

The management of complex gastroschisis with intestinal perforation, intestinal atresia and liver protrusion can be challenging. The optimal timing and method of repair is still unknown for the complex abdominal wall defects. The finding of intestinal complication almost always dictates the method of abdominal wall closure and intestinal procedure. In case of VAD, silo placement with delayed closure was considered. Typically, these patients begin with reduction of herniated contents with abdominal wall closure and repair of intestinal complications. In cases where there is failure to reduce due to severe VAD, the morbidity is increased. Many different surgical techniques are utilized to close the abdominal wall defect such as negative pressure wound therapy[15,16], component separation technique[17,18]. There is no consensus about the best surgical management for this anomaly.

The present study introduces an alternative technique of SSP as part of a delayed repair of complex gastroschisis. The first AWR placement could preformed at bedside. Half of the patients AWR placements were performed in the operating room due to complexity of the eviscerated contents (two with colonic atresia, one with liver protrusion). The AWR was inserted underneath the abdominal wall without suturing. This device could hold for long period to allow improved bowel swelling and preserve abdominal wall tissue.

In infants with intestinal atresia, the proximal end of the atretic part was severely dilated, an enterostomy and SAS placement should be performed simultaneously at the second operation. Synder et al[19], abandoned the combination of enterostomy and staged abdominal wall repair with exposed artificial sheets, because it was difficult to prevent contamination and infection of the exposed artificial sac[20]. In the present study, no infection of the artificial sac and skin was found because the base of the sac was covered with gauze soaked in povidone iodine solution and sterile dressing. Enterostomy promoted external drainage of intestinal contents and decreased bowel swelling, causing possibilities to complete reduction of eviscerated contents. In case of liver herniation (case No.6) (Figure 3), AWR was left in place for 22 days. The liver did not decrease in size and reduction could not progress. The authors performed SAS placement as the second silo placement and continued reduction in vertical direction. Previously, the problem of width diameter of the SAS after complete reduction, the

Table 2. Demographic data and surgical procedure of patients with SSP and RSI (n=6)

Patient	Sex	GA (weeks)	Birth weight (g)	Apgar score	Maternal age (years)	Complication	Age (days)	Surgical procedure	Postoperative complication	1st feed (days)	FF (days)	No. of ventilator day	PPN (days)	LOS (days)
1	Male	37	2,730	9, 10	18	Ileal atresia	1	AWR placement (bedside)		35	42	21	35	45
							12	SAS placememt, ileostomy						
							22	Abdominal closure with Vicryl mesh						
							205	Closure of ileostomy						
2	Male	33	1,900	6, 8	22	Ileal atresia	1	AWR placement (bedside)	• Prolonged paralytic ileus • Ventilator associated pneumonia	34	55	25	50	62
							8	SAS placememt, ileostomy						
							17	Abdominal closure						
							181	Closure of ileostomy						
3	Male	37	3,070	9, 10	22	Colonic atresia	1	AWR placement		41	48	8	39	50
							16	SAS placememt, colostomy						
							31	Abdominal closure with Vicryl mesh						
							255	Closure of colostomy						
4	Male	36	2,105	4, 7	17	Colonic atresia	1	AWR placement (bedside)	• Prolonged paralytic ileus • PPN induced cholestatic jaundice • Ventilator associated pneumonia	52	62	50	69	82
							16	SAS placememt, colostomy						
							30	Abdominal closure with Vicryl mesh and bilateral relaxing skin incision						
							200	Closure of colostomy						
5	Male	37	2,780	8, 9	20	Colonic atresia	1	AWR placement	• Prolonged paralytic ileus	48	72	9	65	78
							14	SAS placememt, colostomy						
							24	Abdominal closure with Vicryl mesh and Rt. relaxing skin incision						
							195	Closure of ileostomy						
6	Male	33	2,150	8, 9	17	Liver herniation	1	AWR placement	• Prolonged paralytic ileus • PPN induced cholestatic jaundice	57	80	10	73	88
							22	SAS placememt						
							34	Abdominal closure with Vicryl mesh and bilateral relaxing skin incision						
							957	Repair of ventral hernia						

GA=gestational age; FF=full feeding; PPN=partial parenteral nutrition; LOS=length of stay; AWR=Alexis wound retractor and protector; SAS=steri-drape artificial sac

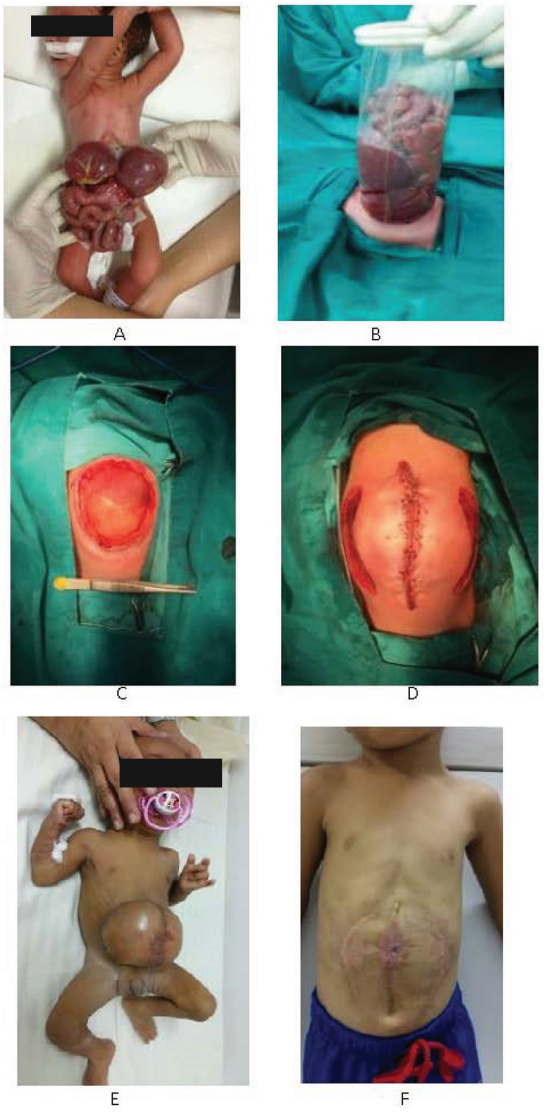

Figure 3. Case No.6, (A) Total liver and intestinal herniation, (B) AWR placement in operating room, (C) Bridging the fascial defect with Vicryl mesh, (D) Bilateral relaxing skin incision to performed adequate skin closure, (E) Large ventral hernia after abdominal wall closure, (F) Five months after repair of ventral herhia at 3 years old.

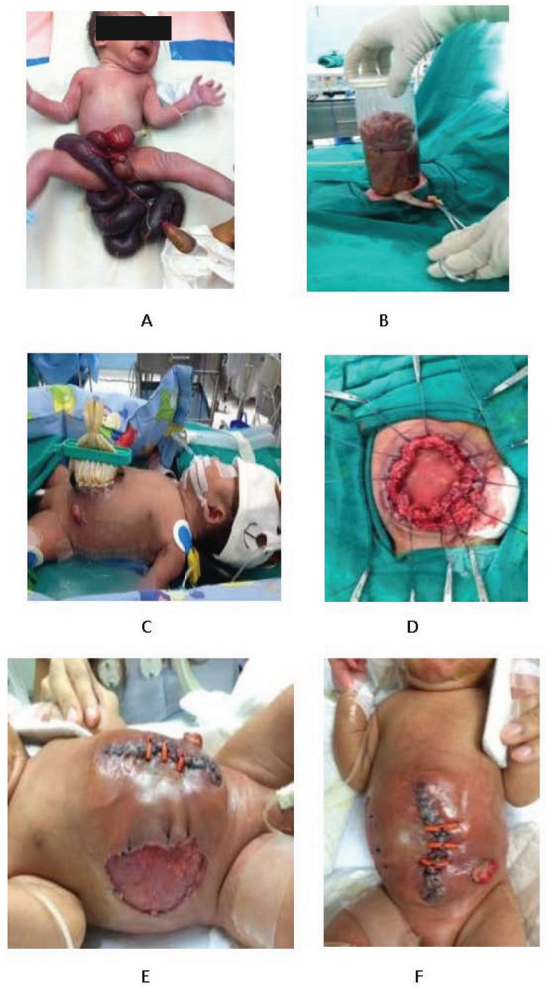

Figure 4. Case No.5, (A) The eviscerated bowel was very dilated with colonic atresia, (B) AWR placement in operating room, (C) Reduction of SAS in vertical direction, (D) Parachute sutured of Vicryl mesh and sheath to bridge the fascial defect, (E) Relaxing skin incision to performed adequate skin closure, (F) Complete skin closure.

length of the diameters caused inadequate tissue approximation. Thus, in the present study, the authors reduced the SAS in vertical direction, the upper part of the SAS was clamped by plastic clip. The fascial defect would be in rectangle shape after complete reduction. Synthetic absorbable mesh (Vicryl mesh) was used to support the midline fascial closure in five cases (Figure 4). Four cases with small defect, the defect could heal completely without ventral hernia. No complications associated with mesh was found in the present study (Figure 2). Patients with enterostomy, the RSI was started at the contralateral site of enterostomy to avoid contamination. In case number 5, RSI was performed bilaterally, due to inadequate skin closure. RSI in curvilinear line promoted adequate skin closure. The risk of skin necrosis was prevented by leaving an adequate skin pedicle and incised lateral to rectus abdominis muscle. Secondary wound healing completed within four weeks without secondary suturing. In case of ventral hernia, the hernia can

be repair without difficulty. There was no adhesion of sub-cuticular tissue and intraabdominal contents. The most common post-operative complication is prolonged paralytic ileus especially in RSI patients. Prolonged PPN can caused cholestatic jaundice, which can resolve after discontinuing PPN. All patients get full oral feeding before discharge. There was no home parenteral or tube feeding.

The authors were unable to find any other report of SSP and RSI in abdominal wall defect patients. However, the SSP and RSI of the abdominal wall have many advantages. These do not require resection of the intestine and can be performed safely in low-birth-weight babies with very narrow abdominal wall, regardless of degree of intestinal dilation, edema, site of atresia, and liver herniation. These procedures can decompress the proximal dilated bowel to enable enteral feeding without home parenteral nutrition. The authors prefer to use Vicryl mesh or the fascial closure because it is thin, pliable, and absorbable. Multiple operations were performed to accomplished abdominal wall closure and restored bowel continuity. The authors recommend SSP for gastroschisis with intestinal atresia and severe intestinal dilation. If SSP is inadequate to achieve complete abdominal wall closure in severe VAD patients, SSP and RSI are recommended for complete abdominal wall closure. SSP and RSI procedures are simple, safe, and do not required specific health resources for complex gastroschisis with severe VAD.

There are several limitations to the present study. First, the number of patients was small, which limited the study design. Second, patients selection for this procedure were responsible surgeons preference and the results of the present study might not be generalizable to the general population. Third, the mean follow-up time was 24 months, longer follow-up period would be better to assess the long-term outcomes.

Conclusion

SSP and RSI were utilized to repair complex gastroschisis patients. Functional abdominal wall reconstruction and intestinal function in complex gastroschisis patients are challenging. In case of liver herniation, ventral hernia may develop after reconstruction, but can be corrected later. The present study demonstrates that SSP and RSI are safe and effective modality for complex gastroschisis patients with severe VAD. The authors have not identified any evidence of long-term complications, but further follow-up is needed to evaluate long-term durability.

What is already known on this topic?

Management of complex gastroschisis is challenging. The problems in management of these patients are a greater quantity of operations, delayed in achieving full enteral feeding, increased incidence of prolonged paralytic ileus, longer average hospital stays, and higher mortality rates. There is no consensus indicating which repair technique is superior. Additionally, protocols for the management of these patients are absent in current medical literature.

What this study adds?

This study is the first study about successful surgical management utilizing SSP and RSI techniques in complex gastroschisis patients. The authors utilized simple materials available in operating room. This study demonstrates that SSP and RSI are safe and effective modality for complex gastroschisis patients, which can be applied to the current practice in Thailand.

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Conflicts of interest

The authors declare no conflict of interest.

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