



CASE REPORT

## The use of pre-operative halo traction to minimize risk for correction of severe scoliosis in a patient with Fontan circulation: a case report and review of literature

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### Abstract

**Purpose** Patients with Fontan circulation have increased cardio-respiratory risk during major spinal surgery. We report a case of severe scoliosis with a Cobb angle of 123.3° in a 16-year-old boy with Fontan circulation treated with single stage posterior segmental pedicle screw instrumentation and fusion.

**Methods** Case report.

**Results** The use pre-operative halo-ring traction for a duration of 6 weeks in this case lead to improvement in cobb angle from 123.3°, kyphotic angle 87.1° to cobb angle of 78.0°, kyphotic angle 57.2° (on bending and stress films). The operation was completed in 150 min, blood loss 1050 ml (25 ml/kg), and cell salvage of 490 ml. He was immediately extubated post correction, but monitored in ICU for a day. Total length of stay was 8 days without any perioperative morbidity or allogeneic blood transfusion. Final post-operative radiograph showed a cobb angle of

44.2°, kyphotic angle 22.8°. Follow up at 27 months showed solid union with no significant loss of correction.

**Conclusion** From this case experience, pre-operative halo traction is a useful surgical strategy in patients with Fontan circulation with severe kyposcoliosis to achieve adequate correction without additional osteotomies to minimize the risk of surgical correction.

**Keywords** Scoliosis · Fontan Circulation · Halo Traction

### Introduction

The association between congenital heart disease and scoliosis has been studied [1–3]. Khadhim et al. [4] found high prevalence of scoliosis in patients with Fontan circulation. The Fontan procedure refers to surgery that leads to systemic flow of venous blood to the lungs bypassing the ventricle. The perioperative cardiac and pulmonary complications are high. We are presenting a case of Fontan circulation with severe scoliosis treated with pre-operative Halo traction to minimize peri-operative risk.

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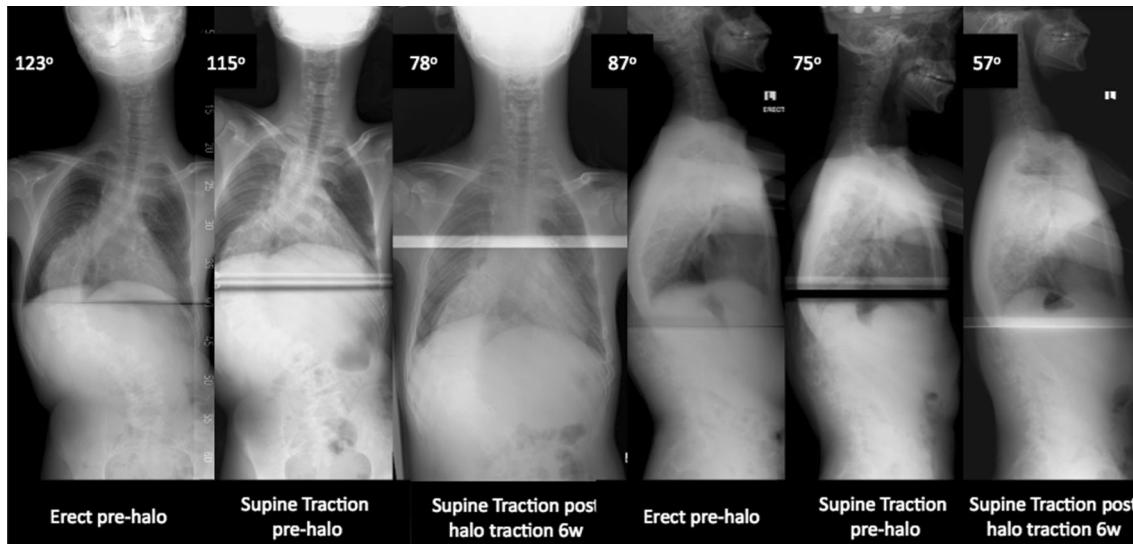
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### Case report

A 16-year-old boy post Fontan operation, presented with progressive worsening of scoliosis. He had Blalock-Taussig (BT) Shunt performed at 6 months old and Fontan operation at 3 years of age. He has a 123.3° thoracic cobb angle (T7–L1) and kyphotic angle of 87.1° (T8–L2). Pre-halo supine AP traction film showed correction to 115.0° (flexibility index 6.5 %) and supine traction lateral radiograph showed correction of kyphosis to 75.4° (flexibility index 13.4 %) (Fig. 1).



**Fig. 1** Radiograph showing AP/lat erect, pre-halo supine AP/lat traction films, and post-traction side bending and lateral traction views

Lung function test showed forced vital capacity (FVC) of 37 % and forced expiratory volume in 1 s (FEV<sub>1</sub>) of 33 %. His vital capacity (VC) and total lung capacity (TLC) were 37 and 33 %. Arterial blood gases showed  $pO_2$  of 65.2 mmHg O<sub>2</sub> saturation of 92.7 % and  $pCO_2$  of 40.0 mmHg. Echocardiogram findings are illustrated in Fig. 2.

Pre-operative halo-ring traction was performed with initial 3 kg load, increased weekly until 16 kg (40 % body weight). Patient was on traction 20 h daily with modification of halo traction, which allowed him to ambulate with a wheelchair (Fig. 3). After 6 weeks of traction, supine side bending films measured 78.0° (flexibility index 36.7 %) and kyphotic angle 57.2° (flexibility index 34.3 %) (Fig. 1). Repeated lung function test after 6 weeks showed FVC of 52 %, FEV<sub>1</sub> of 49 %, VC and TLC were 52 and 58 %, respectively.

The patient underwent single stage posterior segmental pedicle screw instrumented fusion from T4 to L4. Patient received total intravenous anaesthesia (TIVA) with target-controlled infusion of propofol and remifentanil, with infusion rates adjusted to achieve a bispectral index (BIS) between 40 and 60.

Patient was positioned prone on halo-ring traction of 10 kg with SSEP monitoring. To counter the weight of the traction, the patient was positioned head up 20°–25° on the Jackson table. Two spine surgeons performed simultaneous exposure of the spine, insertion of pedicle screws and facetectomy. Operating time was 150 min and patient was haemodynamically stable intra-operatively. Total blood loss was 1050 ml (35.7 % estimated blood volume) with cell salvage of 490 ml.

Fusion was achieved with facetectomy, limited corticotomy (to reduce blood loss), and application of local bone grafts and rhBMP-2 (Medtronic INFUSE® bone graft). Patient was monitored in intensive care unit (ICU) for a day. He was prescribed thoraco-lumbosacral orthosis (TLSO) and discharged on day-8 post surgery. He did not receive allogeneic blood transfusion. The TLSO was worn for 6 months until fusion was confirmed on computed tomography scan (Fig. 4). Final correction was 44.2°, kyphotic angle 22.8°. (Fig. 4) At 27 months follow up, there was no loss of correction, loosening of implants and good clinical outcome.

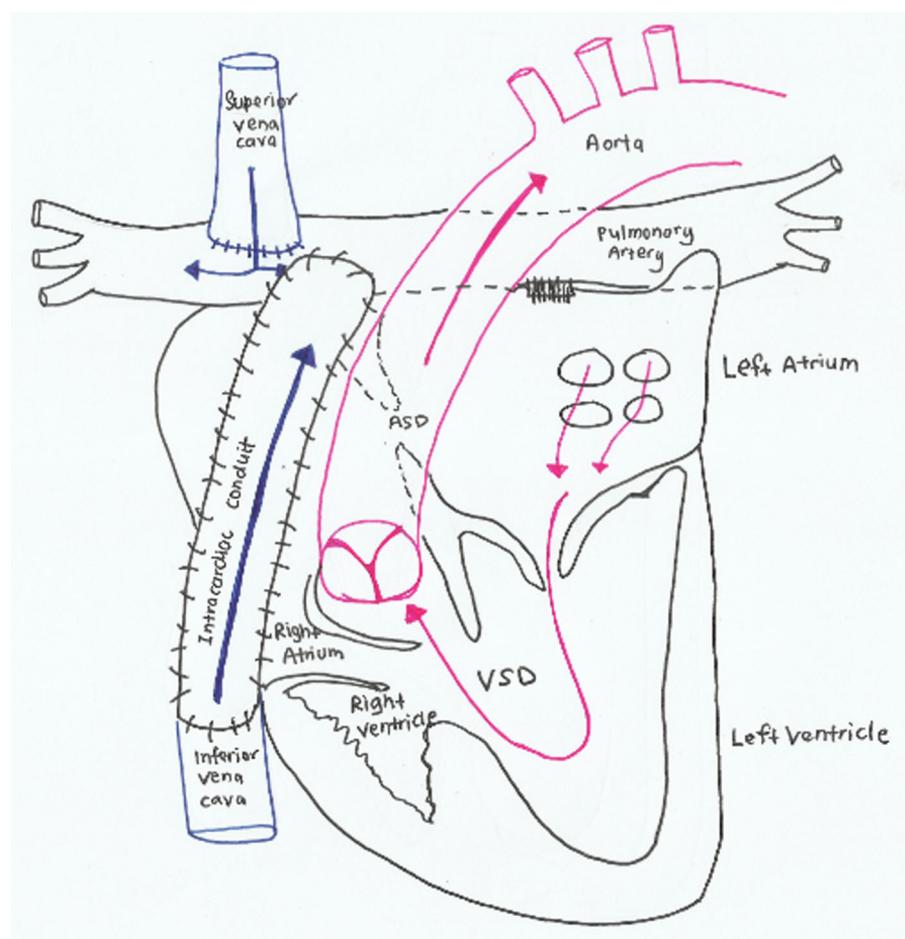
## Discussion

Fontan procedure is done in patients with congenital heart disease not amenable to full anatomical repair. The pulmonary circulation is supplied by the systemic venous return, which needs to be kept high enough to ensure adequate preload.

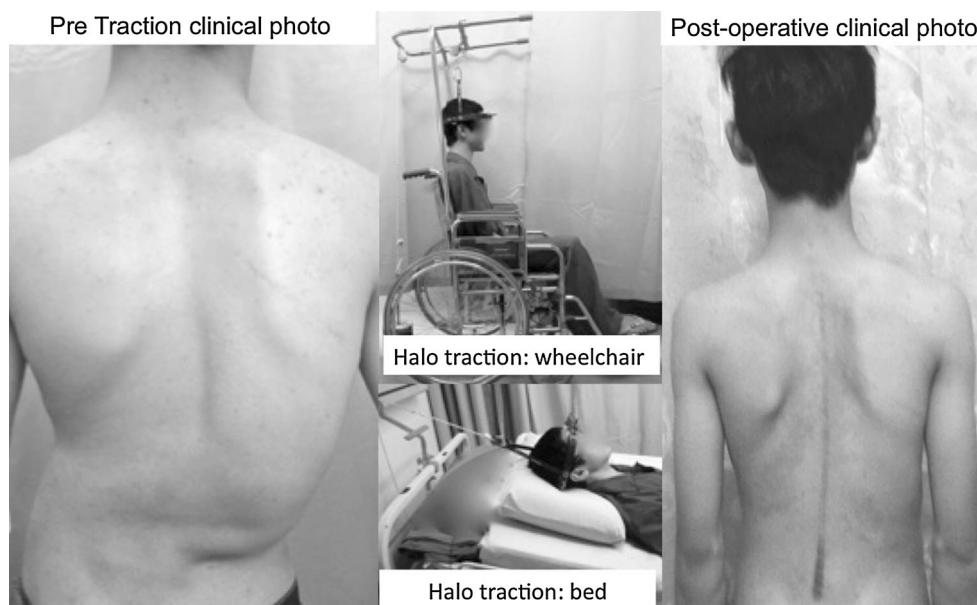
Multiple perioperative complications have been reported, including massive blood loss [5], immediate post-operative death [6], and significant postoperative problems including delayed paralysis and superior mesenteric artery syndrome [7]. Increased pulmonary vascular resistance due to hypoxia, hypercarbia, hypothermia and acidosis should be avoided. As such, intra-operative bleeding and operative time should be minimized.

Clinical data and outcome of scoliosis correction in Fontan circulation is summarized in Table 1. Hedequist et al. [7] reported their post-operative complications

**Fig. 2** Echocardiogram showed inferior vena cava drains into intra-cardiac conduit. Pulmonary vein drains into left atrium. Large inter-atrial communication measuring 14 mm. Double inlet left ventricle with rudimentary right ventricle. There is transposition of great arteries with presence of large ventricular septal defect (15 mm), mild turbulent flow noted. Right superior vena cava flows into right pulmonary artery

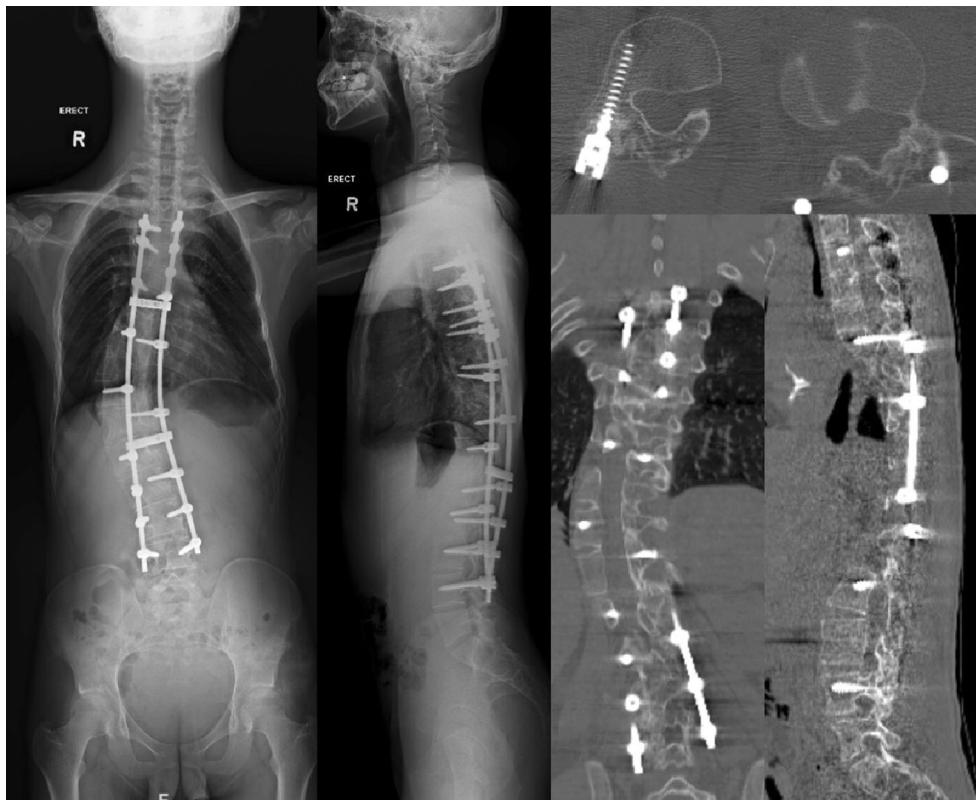


**Fig. 3** Pre and post-operative clinical photo with illustration of halo traction performed while sitting on wheelchair as well as in bed



which are one delayed paralysis, two superior mesenteric artery syndromes, one renal tubular necrosis, two pulmonary complications, one Horner syndrome, and one

urinary tract infection [7]. Their patients also had high amount of blood loss with operative time between 3 and 8 h.



**Fig. 4** Postoperative radiograph showing 64.2 % correction of a 123° scoliosis curve. Computed tomography scan confirmed solid fusion at 6 months follow up post-operation

Leichtle et al. [8] published their report of two patients with Fontan circulation. One developed unstable cardio respiratory condition requiring resuscitation. Their second patient [8] had thoracic scoliosis of 120° and a lumbar curve of 62°. Pre-operative halo-extension was carried out and the patient had good clinical outcome 12 months post-operative with no loss of correction [8].

Evans et al. advocated the use of growing rod technique in patients with Fontan circulation as they found that this technique is associated with less morbidity [9]. Patients who had undergone posterior spinal fusion had blood loss between 37 and 65 ml/kg and one patient had intraoperative hypotension requiring inotropes. [9]. Koller et al. [10] concluded that preoperative halo-gravity traction increased FVC by 9 %. This could reduce risk of pulmonary complications. Gradual traction also allowed surgeons to anticipate haemodynamic changes when correction is performed. Slow correction is safer compared to sudden correction in cases where prior traction was not performed. The use of Halo-Gravity traction in cases of severe scoliosis has been described. Rinella et al. reported improvement of coronal cobb by 46 % after posterior spinal fusion and concluded that traction before surgery was safe and effective [11]. Sink et al. reported an improvement of cobb angle by 35 % just by traction alone and in their series

reduced the coronal cobb angle from 84° pre-traction to 55° post-traction [12]. Sponseller et al. also advocated Halo-Gravity traction in cases of severe spinal deformity and concluded that patients who underwent traction less frequently underwent a vertebral body resection [13]. In a recent publication, the use of continuous skull-femoral traction prior to posterior vertebral column resection (PVCR) was shown to increase the flexibility of the rigid severe curve pre-operatively. In this series of 12 patients with severe and acute sciotic angulation, there were no neurological complications encountered [14].

The case, which is reported here, is the most severe among all the cases reported in terms of coronal cobb angle as well as the sagittal cobb angle. Yet, the intra-operative data shows that the operation is the fastest with the least amount of blood loss. Therefore, we propose that pre-operative halo traction combined with the surgical technique described could potentially reduce the morbidity of such high-risk cases. In such cases, the traditional strategy would be an anterior release with posterior instrumented fusion. In a posterior only approach, additional osteotomies such as Ponte osteotomy or more radical releases would be necessary to obtain correction. This could potentially lead to increased blood loss from the epidural veins and prolonged operative time.

**Table 1** Summary of cases published in surgical literature on scoliosis patient with Fontan circulation

Pt.	Age	Op time	Blood loss (ml/kg)	Procedure performed	Complications	Pre/post cobb
1	Mean Age: 14 years 9 months (12.5–19.7)	Mean operating time: 330 min		(204–540 min) PSF T3–L3	62 Horner syndrome	50/10
2			95	ASF/PSF T9–L4	Acute renal tubular acidosis	90/30
3			208	ASF/PSF T3–L4	1. Superior mesenteric artery syndrome 2. Pleural effusion requiring chest tube placement	94/26
4			51	PSF T1–L2	1. Superior mesenteric artery syndrome 2. Pulmonary edema	80/32
5			33	PSF T3–L2	Urinary tract infection	78/38
6			54	PSF T3–L1	Paralysis at 48-h post-operation	65/79
7	73	PSF T1–L2	None	78/39		
8	14	360	800 ml	PSF T5–L4	Ventricular fibrillation that required intra-operative cardiopulmonary resuscitation (successful resuscitation)	85/60; 70/55
9	16	210	600 ml	PSF T2–L3	None	120/60; 62/30
10	16	Approx. 210	37	PSF (not specified)	Intraoperative hypotension	80/65
11	15	Approx. 480	65	PSF (not specified)	Nil	54/36
12	16	150	25	PSF T4–L4	Nil	123/44

Patient 1–7 from Hedequist et al. 8, 9 from Leichtle et al. 10, 11 from Evans et al. Case 12 is current report

PSF Posterior spinal fusion, ASF Anterior spinal fusion

We have shown that the use of 6 weeks of halo traction has increased the flexibility index from 6.5 % in the coronal plane, 13.4 % in the sagittal plane to 36.7 % in the coronal plane and 34.3 % in the sagittal plane. Therefore, the flexibility of the deformity has been increased by the halo traction. Other benefit, which we report in this case, is the improvement in terms of the pulmonary function. The benefits, which we obtain from pre-operative halo traction, will reduce the potential morbidity from the operative procedure.

Besides halo traction, two surgeons operated independently on both sides to minimize operative time and blood loss. Meticulous haemostasis was also performed during exposure. Corticotomy of the laminae was minimised to reduce bleeding. rhBMP-2 was applied to enhance fusion. Using this strategy, the peri-operative period was uneventful with minimal blood loss (lowest in the series) and short operative time (lowest operative time in the series). The patient did not require any allogeneic blood transfusion. At 27 months, there was solid fusion with no loss of correction.

## Conclusion

From this case experience, pre-operative halo traction is a useful surgical strategy in patients with Fontan circulation with severe kyphoscoliosis to achieve adequate correction

without additional osteotomies to minimize the risk of surgical correction.

## Compliance with ethical standards

**Conflict of interest** None of the authors has any potential conflict of interest

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