Safety advantage of modified minimally invasive cardiac surgery in pediatric patients

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Abstract

Minimally invasive cardiac surgery (MICS) with small surgical incision in children provides less physical stress. However, the concern about safety due to the small surgical field has been pointed out. Recently, we developed a modified procedure of MICS to extend the surgical field. In this paper, we assess the safety and benefit of our modified procedure by comparison among the following three procedures: our modified MICS (group A), conventional MICS (group B), and traditional open heart surgery (group C). A total of 111 pediatric patients (0-9 years-old, 5-30 kg) ,who underwent cardiac surgery for simple cardiac anomaly since 1996 to 2010 at Juntendo University Hospital, were retrospectively analyzed. Modified MICS method to extend the surgical view has been performed since 2004: a skin incision within 5 cm was made below the nipple line, and the surgical field was easily moved pulling up or down using a suture or a hemostat. In the results, there were no differences based on gender, age, weight, and aortic cross clamp time among groups. ANOVA analysis indicated that there were significant differences in mean time before CPB, CPB time, operation time, and bleeding. In the indices, modified MICS group was similar to traditional open surgery and shorter or lower than conventional MICS group. There were no major mortality or morbidity. In conclusion, our modified procedure of MICS, which requires no special techniques, was as safe as conventional open heart surgery, and even reduced perioperative morbidity.

Key words: minimally invasive cardiac surgery, congenital heart disease, ministernotomy, drainage tube

Introduction

Minimally invasive cardiac surgery (MICS) for children has two meanings. One is “off-pump MICS”, which is performed without cardiopulmonary bypass (CPB) during surgery [1], and the other is “ministernotomy”, which is done with smaller skin incision compared to a conventional surgery [2]. The indication for off-pump surgery is limited since the anomaly generally exists inside the heart, in which case the use of CPB is often required. On the other hand, ministernotomy is reported to have advantages not only in better cosmetic outcome, but also in fewer incidences of infection and shorter hospital stay, resulting in better quality of life [3]. Hence, the main interest in MICS for pediatric cases should be ministernotomy for its benefits of reduced physical stress and mental trauma from the wound, . However, many surgeons are still concerned about the safety of MICS, because it is undergone with limited surgical field compared to a “wide-open” surgery. Recently, we developed a new method to obtain a flexible and wide surgical field without any requirement for special training. Moreover, we also developed a novel method for drain tubing. In this paper, we retrospectively compared the three methods: our modified MICS, conventional MICS and traditional open heart surgery to assess whether the new method has advantages in safety.

Materials and Methods

A total of 111 pediatric patients (0-9 years-old, 5.5-28.1 kg) who underwent cardiac surgery for simple cardiac anomaly were analyzed. A single surgeon performed all of these cases as a primary operator from 1996 to 2010 at Juntendo University Hospital. These patients were categorized into three groups; MICS after induction of our modified methods (modified MICS; group A, n=30), MICS before induction of the new methods (conventional MICS; group B, n=35) and traditional open heart surgery (non-MICS; group C, n=46). To evaluate the outcome of surgery, the following indices were analyzed: duration until the initiation of cardiopulmonary bypass (time before CPB), aortic cross clamp time (ACC time), duration of CPB (CPB time), operation time, bleeding volume and hospital stay after surgery.

MICS procedures were introduced in our hospital in 2001. The definition of a conventional MICS procedure is that less than 5 cm of skin incision is made on the midline of the chest below the nipple line. This procedure has been modified to the present form since 2004. Our modified MICS procedure is performed using subdermal undermining to obtain a wide and flexible surgical field with the same criteria of incision as conventional MICS. Followed by partial sternotomy with a sternal saw, the remaining portion of the sternal bone is cut with scissors leaving 1 cm from the top of the bone. A special retractor with a narrow grip on both sides was set to hold the sternal bone tightly, obtaining a stabilized surgical field. An inferior vena cava (IVC) cannula was inserted followed by an aortic cannula insertion to avoid frequent movement of the surgical field. The skin was held in place using a suture hooked to a hemostat

(Fig 1). When operating on the upper side of the wound, skin was pulled up by the suture. The surgical field was easily moved by loosening the suture.

Drain tubing

To minimize the surgical wound, we placed the drainage tubes in the same wound of the skin incision. Drainage tube was inserted at the lower edge of skin incision. We dissected subcutaneous to about 2 cm below the lower edge, and passed the tubes through Linea Alba of the abdominal rectus muscle (Fig 2). We used a soft and flexible tube to prevent it from kinking under the skin, and the tube is fixed by a mattress suture.

Statistical analysis

Data are presented as mean ± SD. Analysis was performed by the SPSS software (version 8, SPSS Inc., Chicago, USA). Intergroup comparison was done using one-way ANOVA. A value of $p<0.05$ was considered as statistically significant. Post-hoc was performed using Fisher's least significant difference.

Results

Patient characteristics are shown in Table 1. Among the patients, there were 64 boys and 47 girls. The mean age was 3.1 ± 2.5 years (range from 0 to 9 years). The mean body weight was 12.5 ± 5.6 kg (range from 5.5 to 28.1 kg). There were no differences in gender, age or weight among the three groups. The surgical procedures in each group are shown in Table 2. There were no statistical differences among the groups. Figure 3 shows the perioperative indices (Fig3). ANOVA analysis indicated that there were significant differences in mean time before CPB, CPB time, operation time, and bleeding. The mean time before CPB was longer in conventional MICS (group B) than that in non-MICS (group C), but it was improved in modified MICS (group A) (groups A vs B vs C: 56 ± 13 vs 74 ± 14 vs 54 ± 10 [minutes], $p<0.05$). The mean CPB time was the longest in group B (51 ± 18, 67 ± 25, 53 ± 27 [minutes], $p<0.05$). ACC time was not different among the groups (33 ± 15, 42 ± 27, 33 ± 18 [minutes], $p=0.11$). The mean operation time was longer in group B (185 ± 33 minutes, $p<0.05$) than in other groups (A: 150 ± 24, C: 154 ± 28 [minutes]). The bleeding volume was highest in group B (18.6 ± 11, 35 ± 39, 19 ± 16 [mL], $p<0.05$). The duration of hospital stay tended to be shorter in group A than that in group C (A: 3.7 ± 0.5, B: 4.7 ± 0.9, [day], $p<0.05$), and there was no significant difference between group A and B. There were no wound infections or hernias in the abdomen or diaphragm, and no reoperation due to bleeding or residual defects was performed. Furthermore, no mortality was noted in this series of patients who underwent MICS procedures.

An example of the cosmetic outcome of the modified MICS procedure is shown in figure 4 (Fig 4: 6 year-old girl, 1 week after surgery). Operative scar would be hidden under swim suits, and no other wounds (drain hole scars) are seen.

Discussion

Minimally invasive approach in cardiac surgery was first reported for the repair of ASD by Bichell in 2000. As experience in ministernotomy grew, the approachit was applied in the treatment of other congenital cardiac defects [4]. Other less invasive approaches to minimize skin incision have also been developed, e.g. ministernotomy, [5, 6] a transxiphoid approach without sternotomy [7], anterolateral thoracotomy [8, 9], postrateral thoracotomy [10], and minimal right vertical infraaxillary thoracotomy [11]. However, there are still concerns about safety in conventional MICS procedures. Since MICS are generally performed in small surgical fields, there are potential risks in dealing with accidents during surgery such as unexpected bleeding. In fact, there are some reports describing troubles cannulating the ascending aorta and controlling bleeding from deep points [12]. In addition, it has also been reported that the right inferior approach prevents the mammary gland from developing which will be a problem especially for female patients [13]. On the other hand, some procedures such as robotic surgery or video-assisted surgery require special devices and training to perform. For these reasons, it might carry a risk for trainees to perform conventional MICS.

The present study showed that the limited access with ministernotomy was not associated with increased perioperative morbidity. The safety of modified MICS procedures was also confirmed as compared with traditional open heart surgery. The duration until the initiation of CPB, which was significantly prolonged in the conventional MICS procedures, was improved in the modified MICS. The

duration of CPB was significantly shorter in the modified MICS group, which resulted in shorter operation time. This may have been caused by the learning curve, because we only use mid-sternotomy approach and no CPB was used through the groin for all procedures in this study, even in the MICS procedure. In addition, we have completely converted from conventional MICS to modified MICS in 2004. But it may also indicate the superiority of modified MICS over conventional MICS in obtaining a wide surgical field, which achieved shorter operation time and less bleeding resulting in shorter hospital stay after operation. Furthermore, in modified MICS, the surgical field was flexible and the incision could be immediately extended in case of emergency. The surgical view in a modified MICS was very similar to that in a conventional approach. Therefore, the surgeon could deal with troubles during an operation in a familiar surgical view.

The main advantage of MICS is the improvement in cosmetic result [9]. It may attenuate both physical and mental trauma, not only for young patients but also for their parents. In our modified approach, skin incision was less than 5 cm with no extra incisions for drainage tubes, which may also have served to reduce the risk of infection. Until now, no deep surgical site infection has been recognized in our MICS experience.

Our modified procedure may also have an educational benefit. Modified MICS, unlike conventional MICS, does not require the surgeon to have special training nor to use special devices except a sternal retractor with simple modification. This could bring back opportunities, which were once taken away

with the introduction of conventional MICS, for young surgeons to safely operate on simple cardiac anomaly such as ASD or VSD.

In conclusion, our modified procedure for MICS, which requires no special techniques, was as safe as conventional open heart surgery, and even reduced perioperative morbidity.

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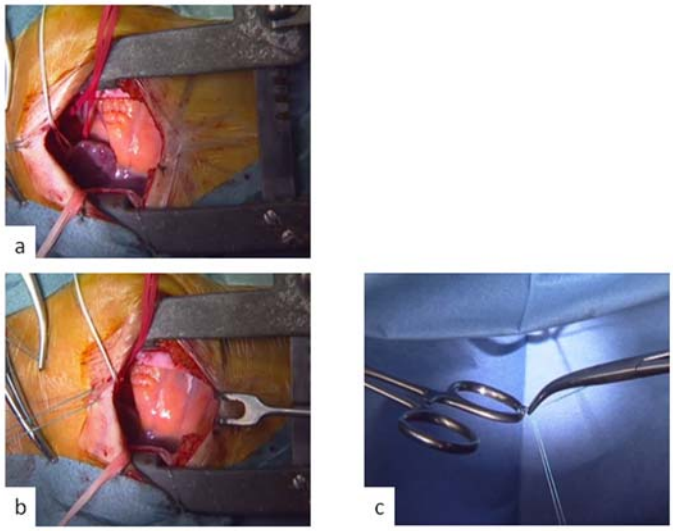
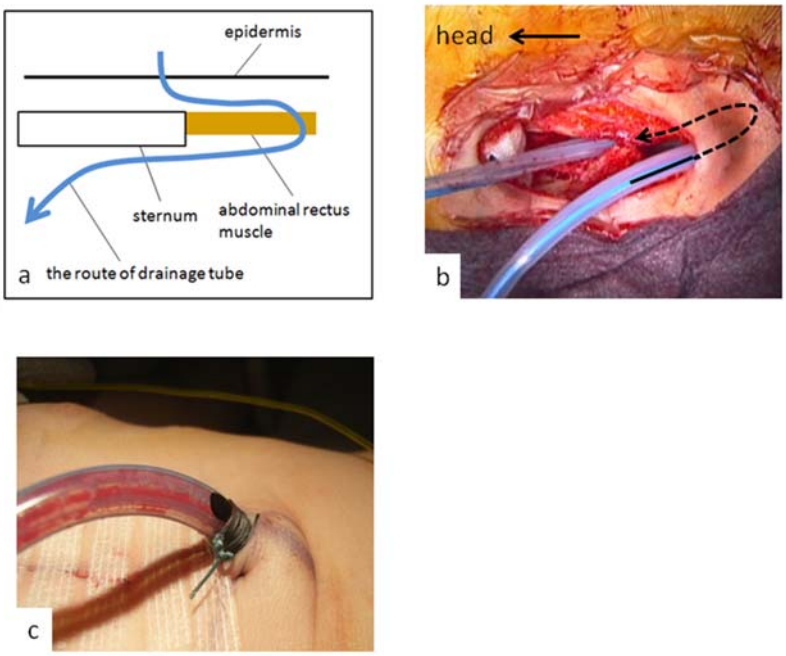
Figure legends

Fig 1



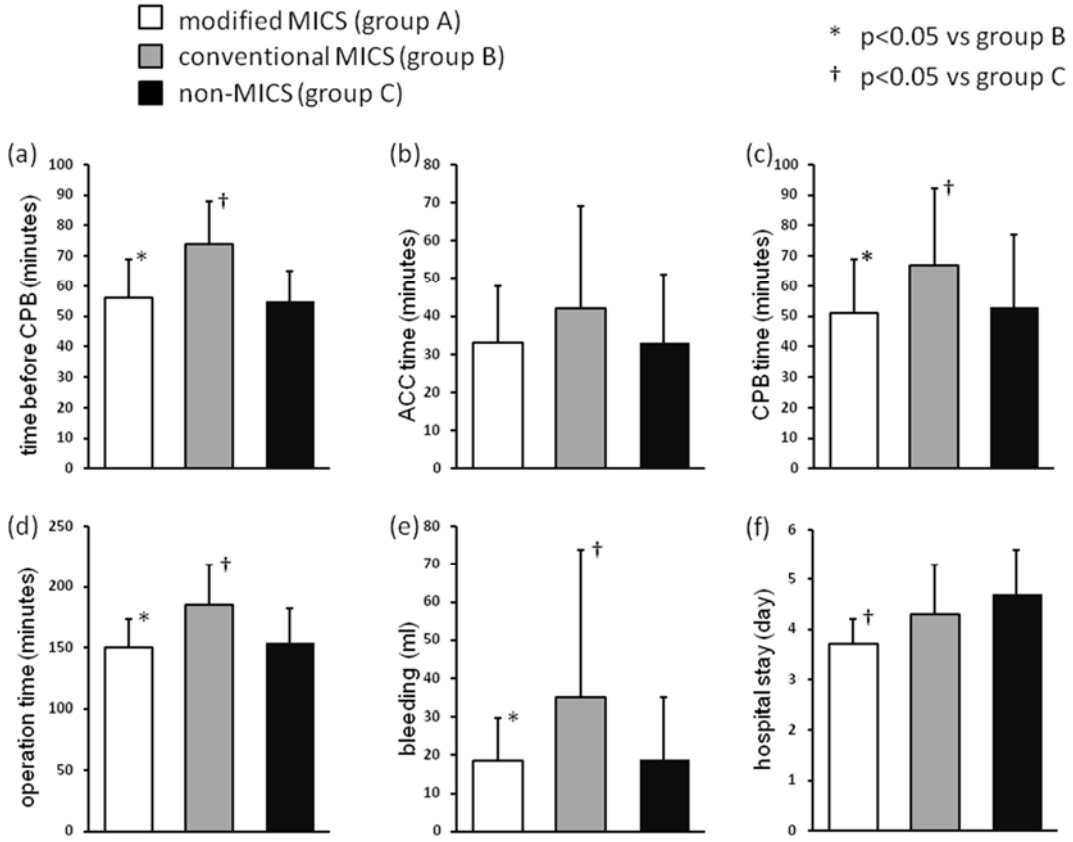
Upper side of the surgical field. A suture is used to pull up the skin (a). Lower side of the surgical field. The field was obtained easily by loosening the suture (b). The other side of the suture is hooked to a hemostat (c).

Fig 2



(a) Scheme for drainage tube insertion. The tube (blue line) was inserted to pass through the skin tunnel, the Linea Alba of abdominal rectus muscle, and then placed into pericardial cavity. The skin tunnel was made from the lower edge of skin incision to about 2 cm below. The drainage tube was then entered into muscle layer. (b) Actual image of insertion of drainage tube. The front edge of the tube would be cut to be proper length followed by placed into pericardial cavity. (c) The tube is fixed by mattress suture.

Fig 3



Comparison among the three methods. White bar indicates modified MICS; gray bar, conventional MICS; and solid bar, non-MICS surgery. *p<0.05, between A and B, † p<0.05, between A and C.

Fig 4

Cosmetic outcome at 4 weeks after surgery in a 6 year-old girl patient. Usually skin incision is hidden under normal T-shirts or U-neck type clothes. In addition, no drain wound exists, since a chest tube was inserted in the lower edge of the incision.