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Delayed abdominal closure after congenital diaphragmatic hernia repair

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ABSTRACT

Purpose: We present our experience with CDH patients who required delayed abdominal closure following CDH repair.
Methods: A retrospective review of all CDH repairs from 2004 to 2014 was performed.
Results: 233 patients underwent CDH repair, of which 21 required delayed abdominal closure defined as the inability to close the abdominal fascia at the time of CDH repair. The incidence of delayed closure was higher in those undergoing CDH repair on ECMO vs. not on ECMO (40% [17/43] vs. 2% [4/190]; $P < 0.001$). The abdominal wound was temporarily covered by skin only ($n = 2$), skin + prosthetic mesh sutured to the fascia ($n = 3$), preformed silo ($n = 9$), or vacuum assisted closure (VAC®) device ($n = 7$). The mean time to fascial closure was 14.5 ± 7 and 6 ± 3 days for patients repaired on ECMO and not on ECMO, respectively. In patients repaired on ECMO, the "primary closure" and "delayed closure" groups were not different in prenatal predictors (liver up, lung-to-head ratio [LHR]), total days on ECMO, ECMO days prior to CDH repair, and survival. In patients repaired on ECMO, the "delayed closure" group had a significantly higher requirement for blood transfusions compared to the "primary closure" group (mean 87 ± 35 vs. 62 ± 27 ml of packed RBCs per ECMO day; $P = 0.01$).
Conclusion: Delayed abdominal closure was required in 40% of CDH repairs done on ECMO but was rarely required in CDH repairs performed off ECMO. Although associated with an increased need for blood transfusions, delayed closure following CDH repair on ECMO was not associated with increased mortality.

Congenital diaphragmatic hernia (CDH) results in the herniation of abdominal viscera into the chest during fetal development. As a result, it is frequently associated with limited intraabdominal domain and therefore a potential mismatch between the volume of viscera needed to be reduced and the size of the abdominal cavity at the time of CDH repair. Techniques to expand the abdominal wall, including manual stretching and fasciotomies, can be helpful but are not always adequate. This is particularly true in CDH patients with edema and abdominal wall swelling such as those on extracorporeal membrane oxygenation (ECMO). Inappropriate closure of the abdominal wall in instances of limited intraabdominal domain increases the risk of wound dehiscence and abdominal compartment syndrome (ACS) with its associated morbidity and mortality [1–5]. When closing the fascia is not feasible, sterile containment of the intraabdominal organs via a temporary closure is required until the abdominal wall becomes compliant and amenable to final abdominal fascial closure. Temporary closure options include fascial closure with mesh followed by skin closure, skin closure only, and leaving the fascia and skin open while containing the abdominal viscera in a preformed silo or under a vacuum assisted closure device. We present a single institution review of all open cases of CDH repair over an 11 year period focusing on the incidence of delayed abdominal closure, the methods of closure and predictors of the need for delayed abdominal closure.

1. Materials and methods

We conducted a retrospective chart review of all patients who underwent CDH repair from 2004 to 2014 at The Children's Hospital of Philadelphia with Institutional Review Board approval (IRB 06-003779_AM46).

Prenatal records were reviewed for CDH side (right vs. left) and severity as assessed by liver position and lung-to-head ratio (LHR) on detailed sonographic evaluation and ultrafast fetal MRI as previously described [6]. Postnatal records were reviewed for birth weight, CDH side, need for ECMO, timing of CDH repair, management of abdominal wall closure and postnatal outcome. Values are represented as the mean ± 1 SD for normally distributed data and as the median (range) for nonnormally distributed data. Statistical comparisons between groups were performed using the Student *t*-test for 2 samples assuming unequal variance when data were normally distributed. For nonnormally distributed data, the Kruskal–Wallis and Mann-Whitney *U* tests were used to identify differences between means. Fisher's exact test was used to compare factors expressed as categorical values. $P \leq 0.05$ was considered significant.

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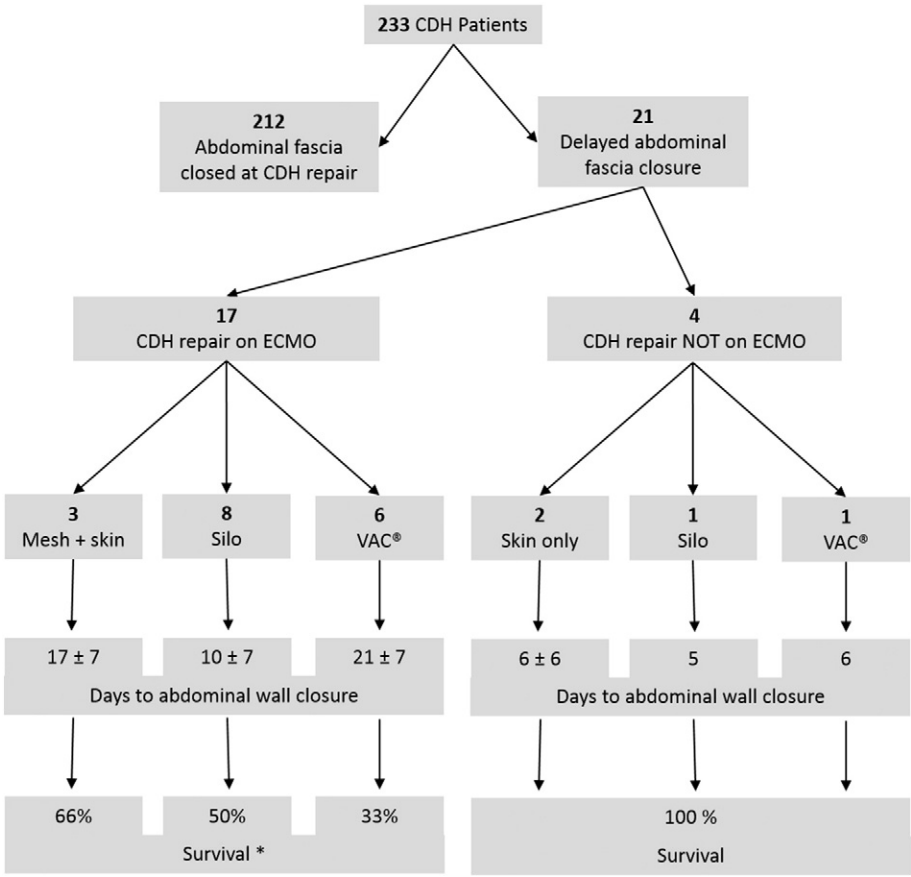

Fig. 1. Operative management and outcomes of CDH patients who underwent primary abdominal wall closure vs. delayed abdominal wall closure. *$P > 0.05$ comparing modes of temporary abdominal closure.

2. Results

Two hundred thirty-three patients underwent CDH repair (Fig. 1). Of them, 9% (21/233) required a delayed abdominal closure owing to the inability to close the abdominal fascia at the time of CDH repair. The incidence of delayed abdominal closure was significantly higher in those undergoing repair on ECMO vs. not on ECMO (40% [17/43] vs. 2% [4/190]; $P < 0.001$). Delayed abdominal closure was also associated with worse prenatal predictors of severity, a higher need for a patch to repair the diaphragmatic defect, a longer hospital stay and a lower survival rate compared to primary abdominal closure in all patients (Table 1). The abdominal wound was temporarily covered by skin closure without fascial closure ($n = 2$), skin + prosthetic mesh sutured to the fascia ($n = 3$), preformed silo ($n = 9$) (Bentec Medical, Woodland, CA), or vacuum assisted closure (VAC® device: KCI, San Antonio, TX) ($n = 7$). The mean time to fascial closure from the time of CDH repair in those patients undergoing delayed abdominal closure was 11.9 days (14.5 ± 7 days for patients repaired on ECMO vs. 6 ± 3 days for patients repaired not on ECMO; $P = 0.02$). Although survival was lower in patients undergoing delayed abdominal closure compared to primary closure, no significant difference in survival was seen in patients undergoing delayed closure based on the method of temporary abdominal closure (Fig. 1).

The most significant correlation with the need for delayed abdominal closure was CDH repair on ECMO. There was no significant difference in prenatal predictors of CDH severity, total days on ECMO, ECMO days prior to CDH repair, ratio of the weight at surgery to birth weight, and survival between those undergoing primary abdominal closure compared to those who underwent delayed abdominal closure following CDH repair on ECMO (Table 2). However, the delayed closure group had a significantly higher requirement for blood transfusions compared to the primary closure group. On further analysis, the requirement for blood transfusion was dependent of the method of temporary abdominal closure (packed RBC per ECMO day: Silo — 80 ml [53–153 ml], VAC® — 94 ml [65–168 ml], mesh + skin — 50 ml [48–54 ml]; differences between subgroups were statistically significant for silo vs. mesh + skin [$P = 0.02$] and VAC® vs. mesh + skin [$P = 0.02$], but not for silo vs. VAC® [$P = 0.7$]). There was also a higher incidence of delayed abdominal closure in patients with left (16 of 35) vs. right CDH (1 of 8), although this did not reach statistical significance. Ninety-three

Table 1
Delayed vs. primary abdominal closure on all CDH patients.

All patients ($n = 233$)	CDH side	Liver Up	LHR	Repair on ECMO	CDH repair with Patch	LOS	Survival
Delayed abdominal closure ($n = 21$)	L = 20 R = 1	18 (86%)	1.09 ± 0.47	17 (81%)	17 (81%)	72 (26–340)	57.1%
Primary abdominal closure ($n = 212$)	L = 179 R = 33	106 (50%)	1.34 ± 0.56	26 (12%)	120 (57%)	39 (6–223)	92.4%
P value	0.32	0.002	0.038	0.001	0.03	0.001	0.001

LOS: length of hospital stay is expressed in days. CDH repair with patch indicates the number of patients in which the CDH was repaired using a patch.