Ventricularseptal defect surgical closure using continuous versus interrupted suturing techniques

Samy Amin, M.D, Ihab Elshehi, M.D, Omar Dawoud, M.D and David Zarif Sobhy, M.Sc.

Cardiothoracic Surgery Department Faculty of Medicine, Cairo University, Egypt.
Email: samymamin@yahoo.com
Samyamin@kasralainy.edu.eg

Abstract: Ventricular septal defect (VSD) repair is the most commonly performed pediatric cardiac operation. Recent reports have indicated a very low incidence of postoperative complications. Some surgeons prefer the running suture technique for VSD closure; others, the use of the interrupted suture. **Patients and Methods:** This study is an observational retrospective study that was conducted at the Kasr Al Ainy Hospitals (Abul Reesh Specialized Pediatric Hospital), Cairo University. Fifty patients studied were used through medical records in the period from January 2015 to August 2017. Patients were divided into two matching groups: Group A contained 25 patients using continuous suture technique while group B contained 25 patients with interrupted suture technique. **Results:** Residual shunt was found in 4% of the interrupted group while, it was found in 12% of the continuous group with no significance between two techniques. Nodal rhythm occurred in 4% in the interrupted group and 8% in the continuous group and all of them recovered to sinus rhythm postoperatively. Complete heart block occurred in 4% in the continuous group and needed permanent pacemaker and didn't occur in the interrupted group. **Conclusion:** Continuous and interrupted suture techniques are equally effective in closure of VSD.
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Key words: Ventricular septal defect, continuous suture technique, interrupts suturing technique.

1. Introduction

Ventricular septal defect (VSD) is the most common congenital heart disease (CHD) accounting for 20% to 30% of CHD **(Homan and Kaplan 2002).** VSD may occur as an isolated anomaly or as a part of complex of anomaly. VSD repair is the most commonly performed pediatric cardiac operation. Recent reports have indicated a very low incidence of postoperative complications **(Scully *et al.*, 2010)**. In the VSDs that need closure, surgical treatment is aimed at prevention of pulmonary hypertension, endocarditis or in some instances progressive aortic valve regurgitation **(Momma *et al.*, 1984).** Residual VSD may result from insufficient intraoperative exposure or suture disruption with patch dehiscence **(Hennein *et al.*, 1955)** and the type of suturing technique used **(Muthuvijayan and Kumaravel, 2016).** Elements of the surgical technique for VSD closure have remained subject to debate. Some surgeons prefer the running suture technique for VSD closure; others, the use of interrupted suture **(Constantine and Carl, 2002).** These defects may have hemodynamic, financial and psychological impacts on the patients and their parents. They may need reoperation or device closure, drug therapy and antibiotic prophylaxis against endocarditis. Residual shunting < 2mm is expected to disappear spontaneously **(Dodge-Khatami *et al.*, 2007)**. Reoperation should be considered if progressive right ventricular failure and clinical deterioration develop.

The aim of this study was to compare between ventricular septal defect surgical patch closure using continuous suture and interrupted sutures concerning early postoperative residual defect.

2. Patients and Methods

The study includes 50 patients studied retrospectively through medical records in the period from January 2015 to August 2017.

Inclusion criteria:

All Patients with VSD only or associated with other simple anomalies (e.g. Patent ductusarteriosus, Atrial septal defect) who underwent surgical VSD closure. Patients were selected according to the following inclusion and exclusion criteria:

Exclusion criteria:

Patients with ventricular septal defect associated with more complex anomalies. (e.g. Left ventricular outflow tract obstruction, canal defect, etc.)

Preoperative:

All patients were evaluated thoroughly preoperative, intra-operative and postoperative with special attention to preoperative and postoperative echocardiography.

Surgical Technique

Standard cardiopulmonary bypass measures were taken. All VSDs were closed via a right a trial approach. In the continuous group all VSDs were closed by a running suture technique using a double-armed, half-circle needle of 5-0 or 6-0 Prolene. In the interrupted group all VSDs were closed using double-armed, half circle needle of 4-0 or 5-0 polyester with teflonpledgets. The closure of the VSD was done with a patch made of Gore-Tex. Associated simple cardiac anomalies as ASD closed by direct running sutures. Weaning of CPB was done after establishment of regular rhythm and stable hemodynamic. The chest was closed routinely after placement of pacing wires, mediastinal and chest tubes.

The intra-operative parameters were:

1- Cross clamp time.
2- Total bypass time.
3- Total operative time.
4- Technique for repair of VSD (continuous or interrupted).
5- Rhythm (sinus, nodal or blocked).
6- Inotropic support.

Post-operative parameters:

All patients were transferred to the ICU on mechanical ventilation with continuous monitoring of HR, blood pressure, urine output and chest tubes drainage.

Postoperative parameters:

1. Mechanical ventilation time.
2. Inotropic support.
3. ICU stay.
4. Residual VSD.
5. Patient's heart rhythm.
6. Postoperative chest infection.
7. Re-exploration.
8. Mortality.

Statistical analysis:

Statistical analysis of the results was a comparison between categorical data [n (%)] was performed using the Chi-square test, Fisher exact test was used instead if cell count was less than 5. Test of normality, Kolmogorov-Smirnov test, was used to measure the distribution of data. Accordingly, the comparison between variables in the two groups was performed using the Mann-Whitney test.

3. Results

A. Preoperative Results:

Demographic features (physical characteristics) of the two study groups.

Table (1) showed that there12 males (48.0%) and 13 females (52%) in the interrupted group while in the continuous group there were 13 males (52%) and 12 females (48%). The mean age for the interrupted group was 12.12 ± 9.98 months while for the continuous group; it was 8.60 ± 5.21 months. The mean weight in the interrupted group was 6.88 ± 3.07 kg, while in the continuous group; it was 6.32 ± 2.15kg.

Echocardiographic of the two study groups

Ventricularlseptal defect type of the two study groups

Regarding the VSD type of the two study groups and from the results in Figure (1), it could be noticed that the interrupted group included 1 (4.0%) inlet type VSD, 12 (48.0%) outlet type VSD and 12 (48.0%) perimembranous type VSD, while the continuous group didn't include any inlet type VSDs, but included 14(56.0%) outlet type VSD and 11 (44.0%) perimembranous type VSD.

Table (1): Demographic features of the two study groups.

Physical characteristics	**Interrupted (n= 25)**	**Continuous (n= 25)**	**P value**
Age (months)	12.12 ± 9.98	8.60 ± 5.21	0.130
Weight (kg.)	6.88 ± 3.07	6.32 ± 2.15	0.772
Sex			
Female	13 (52.0%)	12 (48.0%)	0.777
Male	12 (48.0%)	13 (52.0%)	

Data are expressed as mean ± SD or number (%).

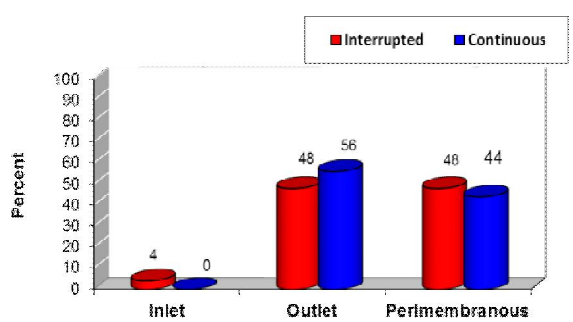

Figure (1): VSD type of the two study groups.

Hemodynamics of the two study groups.

Concerning the hemodynamics of the VSD in Figure (2) the findings illustrated that the interrupted group included 9 (36.0%) restrictive VSDs and 16 (64.0%) non-restrictive VSDs, while the continuous group included 10 (40.0%) restrictive VSDs and 15 (60.0%) non-restrictive VSD.

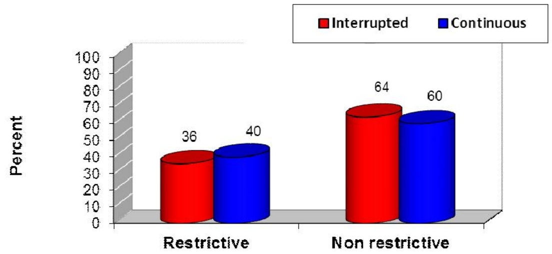

Figure (2): Hemodynamics of the two study groups.

Pulmonary pressure of the two study groups.

The findings from pulmonary artery pressure are reported in Figure (3). The results showed that the interrupted group included 7 (28.0%) normal pulmonary artery pressure patients, 5 (20.0%) mild pulmonary hypertension patients, 7 (28.0%) moderate pulmonary hypertension patients and 6 (24.0%) severe pulmonary hypertension patients, while the continuous group included 10 (40.0%) normal pulmonary artery pressure patients, 2 (8.0%) mild pulmonary hypertension patients, 6 (24.0%) moderate pulmonary hypertension patients and 7 (28.0%) severe pulmonary hypertension patients.

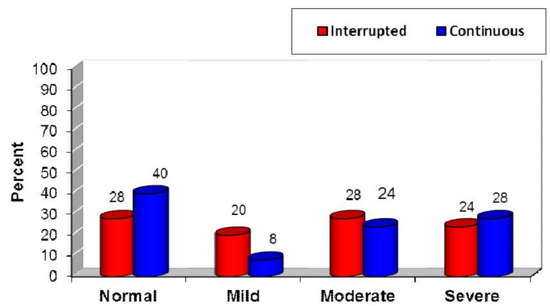

Figure (3): Pulmonary pressure of the two study groups.

Associated anomalies with the two study groups

The finding from the associated anomalies is reported in Figure (4). From the resultant it could be noticed that the interrupted group included 10 (40.0%) isolated VSDs, 5 (20.0%) VSD associated with ASD, 4 (16.0%) VSD associated with PDA and 6 (24.0%) VSD associated with both ASD and PDA; while the continuous group included 7 (28.0%) isolated VSDs, 9 (36.0%) VSD associated with ASD, VSD 4 (16.0%) associated with PDA and 5 (20.0%) VSD associated with both ASD and PDA.

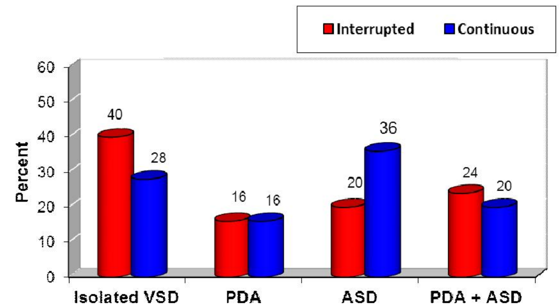

Figure (4): Associated anomalies of the two study groups.

B. Intraoperative results:

Intraoperative results are summarized in Table (2). The results showed that in the interrupted group the aortic cross-clamp time ranged from 36 minutes to 65 minutes with a mean time 45.64 ± 8.07 minutes, while in the continuous group it ranged from 37 minutes to 51 minutes with a mean time 42.48 ± 4.56 minutes with no statistical significance.

In the interrupted group the bypass time ranged from 52 minutes to 90 minutes with a mean bypass time of 64.44 ± 11.43 minutes, while in the continuous group it ranged from 50 minutes to 77 minutes with a mean time 64.28 ± 8.75minutes with no statistical significance.

In the interrupted group the operative time ranged from 95 minutes to 130 minutes with mean time 110.32 ± 10.88 minutes, while on the continuous group it ranged from 93 minutes to 125 minutes with mean time 108.40 ± 9.33minutes with no statistical significance.

Table (2): Mean values of Aortic cross clamp, cardiopulmonary bypass and operative times of the study group.

Intraoperative	**Interrupted (n= 25)**	**Continuous (n= 25)**	**P value**
Crossclamp	45.64 ± 8.07	42.48 ± 4.56	0.270
Bypass time	64.44 ± 11.43	64.28 ± 8.75	0.853
Operation time	110.32 ± 10.88	108.40 ± 9.33	0.785

Data are expressed as mean ± SD.

Table (3) showed that the Intraoperative rhythm in the interrupted group only one patient (4.0%) observed that the ventricular tachycardia which was due to poor myocardial protection, one patient (4.0%) with nodal rhythm,23 patients (92.0%) with sinus rhythm and no patients experienced complete heart block, while the continuous group didn't show any ventricular arrhythmias, but showed one patient (4.0%) with complete heart block and 2 patients (8.0%) with nodal rhythm and 22 patients (88.0%)

with sinus rhythm with no statistical significance between groups.

Table (3): Intraoperative rhythm of the two study groups

Intraoperativerhythm	Interrupted (n= 25)	Continuous (n= 25)	P value
Ventricular tachycardia	1 (4.0%)	0 (0.0%)	0.502
Blocked	0 (0.0%)	1 (4.0%)	0.312
Nodal	1 (4.0%)	2 (8.0%)	0.552
Sinus	23 (92.0%)	22 (88.0%)	------

Data are expressed as number (%).

Moreover Figure (5) illustrated that the Intraoperative inotropic support in each group 21 patients (84.0%) needed intraoperative inotropic support while 4 patients (16.0%) didn't need intraoperative inotropes, so there is no statistical significance.

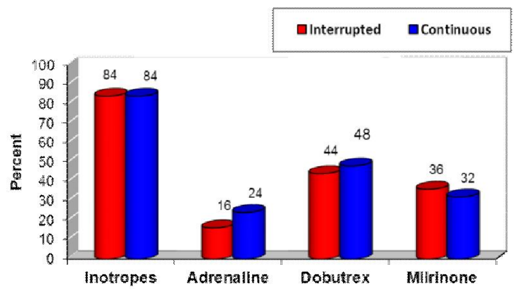

Figure (5): Intraoperative inotropes of the two study groups.

C. Postoperative results:

From Table (4), it could be noticed that the duration of mechanical ventilationin the interrupted group 15 patients (60.0%) were extubated on the same day of surgery, 9 patients (36.0%) were extubated on the first day postoperative and one patient (4.0%) was extubated on the second day postoperative. In the continuous group 14 patients (56.0%) were extubated on the same day of surgery, 10 patients (40.0%) were extubated on the first day postoperative and one patient was extubated on the second day postoperative.

The duration of ICU stay ranged from 4 days to 7 days with a mean duration of 5.04 ± 0.93 days in the interrupted group, while in the continuous group it ranged from 4 days to 17 days with mean duration of 5.68 ± 2.51 days.

Ward stay duration ranged from 0 days to 3 days in both groups with a mean duration of 0.32 ± 0.80 days in the interrupted group and a mean duration of 0.20 ± 0.71 days.

The total hospital stay mean duration was 5.36 ± 1.60 days in the interrupted group and 5.88 ± 2.68 days in the continuous group.

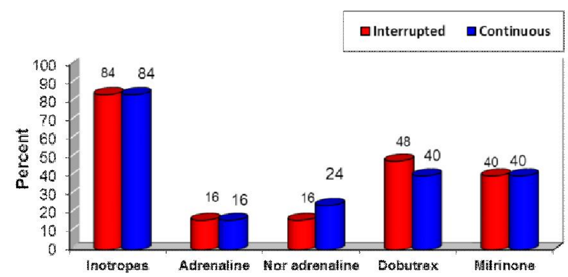

Figure (6): ICU inotropes of the two study groups

Table (4): The mean values of the total period of mechanical ventilation, ICU stay and Ward stay in days and total hospital stay.

	Interrupted (n= 25)	Continuous (n= 25)	P value
ICUstay (days)	5.04 ± 0.93	5.68 ± 2.51	0.269
Totalhospital stay	5.36 ± 1.60	5.88 ± 2.68	0.322
Wardstay (days)	0.32 ± 0.80	0.20 ± 0.71	0.700
0	21 (84.0%)	23 (92.0%)	
1	1 (4.0%)	0 (0.0%)	
2	2 (8.0%)	1 (4.0%)	
3	1 (4.0%)	1 (4.0%)	
Ventilation time	0.44 ± 0.58	0.48 ± 0.59	0.957
0	15 (60.0%)	14 (56.0%)	
1	9 (36.0%)	10 (40.0%)	
2	1 (4.0%)	1 (4.0%)	

Data are expressed as mean ± SD or number (%).

ICU inotropic support is expressed in Figure (6): In each group 21 patients needed inotropic support in the ICU with no statistical significance between both groups regarding the need for support or the type of inotropes used in the ICU.

Postoperative echocardiographic assessment was estimated and the results in Table (5) showed that only one case (4.0%) in the interrupted group that had a residual shunt and it was a 1mm residual shunt. In the continuous group, there were 3 cases (12.0%) with a residual shunt, 2 of them was 1mm and one was 3mm residual shunt which was statistically insignificant.

Table (5): Residual shunt in the study group.

Residual shunt	Interrupted (n= 25)	Continuous (n= 25)	P value
Residual shunt (yes)	1 (4.0%)	3 (12.0%)	0.297
Residual shunt in mm			
1	1 (100.0%)	2 (66.7%)	0.505
3	0 (0.0%)	1 (33.3%)	

Data are expressed as number (%).

4. Discussion

We tracked the course of VSD in 50 patients to detect the difference between interrupted and continuous surgical techniques of VSD closure. 50% of the patients were males and 50% of them were females. There were (48%) males and (52%) females in the interrupted group while in the continuous group there were (52%) males and (48%) females. **Muthuvijayan and Kumaravel (2016**) included in their study 46.4% males and 53.6% females.

The mean age for the interrupted group was 12.12m ± 9.98 months and for the continuous group was 8.60 ± 5.21months. Mavroudis C2010in contrast had a mean age of 53.25 ± 42.92 months for the interrupted group and 49.42 ± 36.46 months for the continuous group. The mean weight was 6.88 ± 3.07 kg in the interrupted group, while in the continuous group; it was 6.32 ± 2.15kg. **Jacobs and O'Brien (2013)** had a mean weight of 16.59 ± 14.29 kg for the interrupted group and 14.91 ± 8.69 kg for the continuous group.

Our patients 34% were found by echocardiography to have isolated VSD,28% associated with ASD, 16% associated with PDA and 22% associated with both ASD and PDA.

The type of the VSD affects the approach for the VSD and the operation time and also affects the results regarding the residual shunt and heart block. In our study group; the majority was outlet VSD (52%), followed by per membranous (46%) and finally inlet VSD (2%).

These results are near **Muthuvijayan and Kumaravel (2016**) who found included study (51.2%) outlet VSD, (46.5%) Perimembranous VSD and (2.3%) Inlet VSD.

Mavroudis and Backer (2010) 80% of VSDs were per membranous, 13% were outlet VSDs, 3% inlet VSDs and 4% muscular VSDs. Also, **Anderson and Stevens (2013)** on the other hand had different results; 79% had perimembranous VSDs, 5.8% had muscular VSDs, 9.9% had outlet VSDs while 5.3% had multiple VSDs.

Our patients 38% had restrictive VSDs and 62 % had non-restrictive VSDs. In contrast to **Muthuvijayan and Kumaravel (2016)** study included 86.1% restrictive VSDs patients and 13.9% non-restrictive VSDs patients.

PHTN was diagnosed in 66% of the patients while 34% of our patients had normal pulmonary artery pressure. **Stevenson and Anderson (2013)** PHTN was diagnosed in 87.6% of the patients. These results also contrast Z**iaeand Farah (2014)** in which only 9.5% of their patients had PHTN preoperatively.

In our study, the mean aortic cross clamp time was 44.1 ±6.7 minutes, it was 45.64 ± 8.07 minutes for the interrupted group and it was 42.48 ± 4.56 in the continuous group, mean bypass time was 64.4 ± 10.1 minutes, it was 64.44 ± 11.43 minutes in the interrupted group and it was 64.28 ± 8.75 in the continuous group and the mean operative time was 109.4 ± 10.1 minutes, it was 110.32 ± 10.88 minutes in the interrupted group and was 108.40 ± 9.33 in the continuous group.

In the study conducted by **Muthuvijayan and Kumaravel (2016)** they reported longer mean aortic cross clamp time for both groups which was 66.49 ± 23.41minutes for the interrupted group and it was 58.52 ± 35.24 in the continuous group and longer mean bypass time for both groups which was 118.15 ± 65.17 minutes in the interrupted group and it was 93.01 ± 37.62 in the continuous group which may be due to presence of more complex anomalies.

Kogonand Butler (2008) reported a shorter mean cross clamp time than our study 38 ± 7.22 minutes. However they reported bypass time near our study 63 ± 5.86 minutes and longer mean operative time 169 ± 5.63 minutes.

VSD was closed using interrupted technique in 50% of the cases, while it was closed using the continuous technique in 50% of the cases.

Muthuvijayan and Kumaravel (2016) used the interrupted technique in 60.5 % of their patients and the continuous technique in 39.5% of the patients. Moreover, **Marshall and Jeffrey (2010)** used the interrupted technique in 29.4% of their patients and the continuous technique in 70.6% of their patients.

Our patients 84% needed cardiac inotropic support intraoperatively and postoperatively. The study conducted by **Mavroudis and Backer (2010)** show that only 42.7% of their patients needed postoperative cardiac inotropes while 57.3% of them didn't receive cardiac inotropes. The difference in number of patients who had inotropic support between our study and other studies can be attributed to that it's an anesthetic policy to put patients on inotropic support for the first few hours postoperatively.

The mean duration of postoperative mechanical ventilation in our study was 0.46 ± 0.58 days; it was 0.44 ± 0.58 for the interrupted group and was 0.48 ± 0.59 for the continuous group.

However, **Ziaeand Farah (2014)** had the mean mechanical ventilation time 1.20 ± 0.49 days, and was 1.17 ± 0.49 in the interrupted group and was 1.22 ± 0.49 days for the continuous group.

Stevens and Anderson (2013) also had mean duration of mechanical ventilation 1.2 ± 0.82 days and the study conducted by Donald B 2012 it was 1.8 ± 0.96 days.

The mean time of postoperative ICU stay was 5.36 ± 2.8 days, it was 5.04 ± 0.93 days in the interrupted group and was 5.68 ± 2.51 days in the continuous group which are longer that results of **Muthuvijayan and Kumaravel (2016) s**tudy in which the mean ICU stay was 2.85 ± 1.18 days, it was 2.78 ± 1.24 days in the interrupted group and was 2.88 ± 1.16 days in the continuous group which may be related to the difference between the mean age and mean weight in our study group in comparison with their study group. **Donald *et al*. (2012)** the mean period of postoperative ICU stay was 3.8 ± 1.51 days.

The difference between our results and other studies can be explained by that most of our patients were discharged home from ICU if they met the following criteria: hemodynamically stable patient, free sepsis profile, all anti-failure medications were taken by the oral route.

In our study 90% of our patients were with sinus rhythm Intraoperative, one patient (2%) got intraoperative VT which was due to poor myocardial protection and returned to sinus rhythm with recirculation, one patient (2%) got complete heart block and he was in the continuous group and needed a permanent pacemaker and 3 patients with a percent of (6%); one of them (2%) in the interrupted group 2 of them (4%) in the continuous group, they all returned to the sinus rhythm in the ICU postoperatively, so postoperative rhythm was sinus in 98% of the patients and complete heart block in 2% of the patients.

Muthuvijayan and Kumaravel (2016) reported Intraoperative sinus rhythm in 89.6% in their patients, 2.2% complete heart block and 8.2% with nodal rhythm. It also reported postoperative sinus rhythm in 83.1% of their patients, complete heart block in 2.2% of their patients and Nodal rhythm in 14.7% of their patients.

Mavroudis and Backer (2010) study 16% of the patients had heart block either transient or permenant. Postoperative echocardiography assessment showed that 92% of our cases had no residual flow across VSD; 2% in the interrupted group and 6% in the continuous group. **Muthuvijayan and Kumaravel (2016)** study had 7% of the patients got residual shunt; 2.35% in the interrupted group and 4.65% in the continuous group.

In contrast to **Mavroudis and Backer (2010)** study whichreported residual shunt 55.4% in their patients; 25% of the patients of the interrupted group had residual shunt and 68.1% of the patients of the continuous group.

10% of the cases only had postoperative chest infection. This is close to the results of the study conducted by **Muthuvijayan and Kumaravel (2016)** where postoperative pneumonia was diagnosed in 13% of the patients.

None of our patients needed reoperation. **Marshall and Jeffrey (2010)** whoreported that, 3.9% of their patients needed re-exploration.

No mortality was recorded in this study. These results agree with the results of **Muthuvijayan and Kumaravel (2016)** who reported no mortalities among their study group. It differsthan observed by **Kogon and Butler (2008)** who reported the mortality was 6.9% of their patient**s.**

Conclusions

Continuous and interrupted suturing techniques are equally effective in the closure of VSD even though residual shunt and complete heart block are common with continuous suture technique of VSD closure and the continuous group is associated with shorter cross-clamp time but with no statistical significance between both techniques.

Conflict of interest:

The author declares that there is no conflict of interest.

Source of funding:

Self-funding

Ethical Clearance:

The patients from kasr Al Ainy hospitals (Abul Reesh specialized pediatric hospital), Cairo University, Egypt.

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