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## Attitudes of Clinicians Towards Cardiac Surgery and Trisomy 18

Meagan Kaulfus

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ATTITUDES OF CLINICIANS TOWARDS CARDIAC SURGERY AND  
TRISOMY 18

by

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ATTITUDES OF CLINICIANS TOWARDS CARDIAC SURGERY  
AND TRISOMY 18

A  
THESIS

Presented to the Faculty of  
The University of Texas  
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in Partial Fulfillment  
of the Requirements  
for the Degree of  
MASTER OF SCIENCE

by

Meagan E. Kaulfus, B.S.  
Houston, Texas

May, 2017

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# ATTITUDES OF CLINICIANS TOWARDS CARDIAC SURGERY AND TRISOMY 18

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## ABSTRACT

Trisomy 18 is an autosomal trisomy characterized by minor to major birth defects, severe disabilities, and high rates of pre- and neonatal mortality. Interventions for these infants have traditionally been withheld with focus instead on palliative support. The issues and attitudes surrounding surgical treatment of congenital heart defects, which occur in approximately 90% of infants with trisomy 18, is of our study's interest as recent literature has indicated that cardiac surgery is being performed and may lead to improved survival compared to palliative care. In this study, the attitudes of clinicians of multiple specialties towards cardiac surgery for infants with trisomy 18 was evaluated along with approaches used by cardiac surgeons to determine candidates for surgery. Of the 378 participants, 48% felt it was appropriate to discuss the option of cardiac surgery. Ethical considerations and insufficient outcome data were the most agreed upon reasons for not offering cardiac surgery in majority of clinicians. Overall, prenatal physicians were more likely to disagree with offering cardiac surgery than postnatal physicians and genetic counselors. Trisomy 18 not being uniformly lethal was the most agreed upon justification among clinicians in support of offering surgery, followed by respect for expression of parental wishes. Cardiac surgeons were more likely to perform surgery on less complex heart defects in the absence of additional anomalies or presence of less severe anomalies. Results from this study do not seek to suggest uniform care for these infants, but aim to promote discussion and collaboration among clinicians to improve patient care.

## TABLE OF CONTENTS

<b>Approval Sheet.....</b>	<b>i</b>
<b>Title Page.....</b>	<b>ii</b>
<b>Acknowledgements.....</b>	<b>iii</b>
<b>Abstract.....</b>	<b>v</b>
<b>List of Figures.....</b>	<b>viii</b>
<b>List of Tables.....</b>	<b>ix</b>
<b>Introduction.....</b>	<b>1</b>
<b>Methods.....</b>	<b>5</b>
<b>Study Participants.....</b>	<b>5</b>
<b>Anonymous Survey.....</b>	<b>6</b>
<b>Data Analysis.....</b>	<b>7</b>
<b>Results.....</b>	<b>7</b>
<b>Demographics.....</b>	<b>8</b>
<b>General Knowledge and Attitudes Towards Trisomy 18.....</b>	<b>10</b>
<b>General Questions Towards Cardiac Surgery     for Infants with Trisomy 18.....</b>	<b>11</b>
<b>Attitudes Regarding Considerations in Offering Cardiac     Surgery.....</b>	<b>12</b>
<b>Cardiac Surgeon’s Approaches Towards Determining Candidates for     Cardiac Surgery.....</b>	<b>15</b>
<b>Free Responses.....</b>	<b>17</b>
<b>Discussion.....</b>	<b>20</b>
<b>Practice Implications.....</b>	<b>25</b>

<b>Strengths and Limitations.....</b>	<b>26</b>
<b>Future Directions.....</b>	<b>29</b>
<b>Appendix.....</b>	<b>30</b>
<b>Bibliography.....</b>	<b>50</b>
<b>Vita.....</b>	<b>55</b>



## LIST OF FIGURES

Figure 1: Clinician attitudes towards considerations in offering cardiac surgery for infants with trisomy 18.....	12
Figure 2: Cardiac surgeons' attitudes towards the influence of other factors in their willingness to perform cardiac surgery on infants with trisomy 18.....	17

## LIST OF TABLES

Table 1: Demographics of clinicians .....	9
Table 2: Comparison of attitudes towards considerations in offering cardiac surgery by clinician type (prenatal physicians, postnatal physicians, genetic counselors).....	13
Table 3: Cardiac surgeons' willingness to perform surgery on infants with trisomy 18 depending on the type of heart defect and the presence of additional anomalies.....	16

## INTRODUCTION

Trisomy 18, or Edwards syndrome, is an autosomal trisomy involving an extra copy of chromosome 18. Following Down syndrome, trisomy 18 is the second most common autosomal trisomy with a quoted prevalence of 1 in 3,000 to 1 in 8,000 live births. Children with trisomy 18 have minor to major birth defects, severe psychomotor and cognitive disabilities, and an increased risk for pre- and postnatal mortality<sup>1, 2</sup>. Due to the presence of multiple anomalies, it is estimated that approximately 5-10% of live born infants with trisomy 18 live to the first year of life<sup>3</sup>. A more recent population-based study reported a one-year life expectancy of 13.4%, however this might be attributed to more aggressive medical interventions being increasingly offered<sup>4</sup>. Survival past one year of life and rarely into the second decade of life has been reported with those individuals experiencing profound cognitive and psychomotor delays<sup>5-7</sup>. Individuals with mosaic trisomy 18 or partial trisomy 18, which make up approximately 7% of cases of trisomy 18, may display a less severe phenotype and a lower mortality rate compared to non-mosaic trisomy 18<sup>2, 8</sup>. Because of the high mortality associated with non-mosaic trisomy 18, medical care has traditionally been palliative rather than aggressive, particularly regarding the surgical repair of birth defects.

Out of the many birth defects seen in infants with trisomy 18, the issues and attitudes surrounding surgery on congenital heart defects (CHDs) is one that remains particularly controversial in the medical literature. CHDs are found in approximately 90% of infants affected with trisomy 18, the most common being ventricular septal defects (VSD), atrial septal defects (ASD) and patent ductus arteriosi (PDA)<sup>9-11</sup> while 10% have more complex CHDs<sup>12</sup>. Heart failure secondary to an unrepaired cardiac defect is considered one of the major causes of deaths in infants with trisomy 18 along with respiratory failure or central apnea<sup>1, 2, 13</sup>. Due to the co-morbidities of this condition, aggressive interventions such as cardiac surgery have

historically been strongly discouraged<sup>14</sup>. Numerous studies<sup>15-18</sup> have provided justification for palliative approaches over surgery, raising concerns such as heart surgery being a poor allocation of the institution's time and resources, harm to the infant during the recovery process such as pain during or post-surgery, limited maternal bonding, harsh environmental stressors, and disturbed sleep wake cycles. Other expressed considerations involve the ethical concerns surrounding surgery for infants with trisomy 18 such as nonmaleficence, beneficence, and justice, the quality of life after surgery, lack of clarity as to whether cardiac surgery truly improves prognosis, and potentially providing false or unrealistic expectations for the families.

Despite these views traditionally discouraging surgical intervention, in the last decade numerous studies<sup>11, 19-22</sup> have described outcomes following cardiac surgery on infants with trisomy 18, most frequently on VSDs, ASDs, and PDAs demonstrating seemingly favorable results. One study<sup>22</sup> found that children with trisomy 18 had a two-year survival rate of 45% after cardiac surgery and another study<sup>23</sup> through the Pediatric Cardiac Care Consortium reported an 86% hospital survival rate in infants with trisomy 18 following surgical repair of a CHD. While there are published recommendations regarding the importance of conversations between clinicians and families regarding the option of cardiac surgery<sup>24</sup>, there is an overall lack of agreement in the published literature for recommendations of cardiac surgery over palliative approaches for moderately complex cardiac defects in infants with trisomy 18<sup>23, 25</sup>. Although numerous studies do claim cardiac surgery potentially helps negate cardiac-related death and has the potential to improve the survival length of infants with trisomy 18 compared to infants that receive palliative care, many argue that more data demonstrating there is a clinical benefit to cardiac surgery needs to be published before generalizations can be made on whether or not to offer surgery<sup>15, 20, 21, 26, 27</sup>. Furthermore, it is important to carefully consider the limitations of the data available on the survival statistics of infants who undergo cardiac surgery. Confounders

may include selection bias of infants who undergo cardiac surgery as they are often selected based on less severe heart defects, absent or mild additional anomalies, and older ages. Most authors on both sides this subject agree that it is unrealistic to conclude that there will be a straightforward answer to this question, as each infant with trisomy 18 and his or her family will need to be considered on an individual basis, not grouped into a syndrome or diagnosis<sup>12, 27-31</sup>. Ultimately, the decision for an infant to undergo cardiac surgery is controversial and requires careful consideration and a thorough understanding by involved clinicians of the benefits and limitations of such intervention.

As this topic has increasingly gained interest within the medical community, research has been performed examining the attitudes of physicians regarding the care and management of infants with trisomy 18. Two different studies on the opinions of neonatologists towards neonatal resuscitation for infants with trisomy 18 found that the expressed wishes of the parents largely drove the decision to perform resuscitation, a finding in favor of parental autonomy as opposed to a strict, palliative care approach<sup>32, 33</sup>. Other studies reinforce this, reporting that the majority of physicians, including obstetricians and gynecologists (OBGYN), maternal fetal medicine specialists (MFM), neonatologists, medical geneticists, and cardiologists, identified that they were likely to respect parental autonomy regarding management decisions in conditions such as trisomy 18 rather than making management decisions based solely on the diagnosis itself<sup>24, 34-37</sup>. While some consistencies have been found among physicians, these and other studies have further identified differences in opinions among and between specialties regarding the care and management of infants with trisomy 18. For example, in one study<sup>36</sup> cardiologists were more likely to recommend interventions including cardiac surgery for infants with trisomy 18 than neonatologists or medical geneticists. Conversely, another study<sup>37</sup> surveying cardiologists in Canada, respondents were more likely to recommend palliative care

and medical treatment of symptoms, not surgical repair of cardiac defects. In another, pediatric pulmonologists were more likely to offer interventions such as full code resuscitation and cardiac surgery compared to neonatologists<sup>38</sup>. These differing opinions among physicians suggests there is not a uniformly accepted standard of care for infants with trisomy 18. Therefore, decision-making surrounding the care and management of these infants should be considered on an individual basis and should not be grouped into a syndrome or diagnosis without consideration of the individual infant<sup>24, 35-37</sup>. As many clinicians are involved in the pre- and postnatal care of infants with trisomy 18 and the discussions with families, additional research is warranted to add to previously described clinicians' attitudes towards this controversial topic in the interest of improving understanding of clinical approach and promoting consistency. When trisomy 18 is diagnosed prenatally, the patient has the option to continue or terminate the pregnancy. For those who decide to continue the pregnancy, discussions of prenatal and postnatal management options should take place between the patient and her healthcare team. These conversations may involve the following specialists: the OBGYN likely to be involved with the delivery process, MFM, neonatologist, prenatal and pediatric genetic counselor and medical geneticist, pediatrician, cardiac specialist in the event surgery is being considered, and depending on the needs of the family, sometimes a chaplain, clinical social worker, or home care providers such as nurses and therapists<sup>30</sup>. While all of these clinicians are important in the care of families with infants of trisomy 18, our study chose to focus on the attitudes of OBGYNs, MFMs, neonatologists, medical geneticists, genetic counselors, cardiologists, and cardiac surgeons.

The topic of cardiac surgery for infants with trisomy 18 is undeniably a very complicated subject in the medical literature and clinical practice, as clinicians strive to provide high standards of patient care while balancing allocation of resources, parental autonomy, and

the best interest of the patient. As no official recommendations exist, guidance for clinicians involved in the pre- and postnatal care of these infants remains limited. Thus, the current discussions with the families may be based on outdated literature or simply lack of knowledge of the available options. Some studies point to the effectiveness and potential benefit of cardiac surgery, while others state that such data is far too limited to draw conclusions about improved outcomes. Such discrepancies ultimately lead to a lack of consistency among clinicians throughout the country and the care given to patients. We aim to improve understanding of why and how some clinicians choose to incorporate the options of cardiac surgery into their discussion, and why others do not, as well as variables that cardiac surgeons may view as influential when considering the surgical candidacy of a patient. By exploring these attitudes, we hope to further stimulate conversations within and among specialties, members of the healthcare team, and perhaps eventually professional societies to promote consistency in the discussions among families and their healthcare team to improve patient care. Thus, this study aims to describe clinicians' attitudes towards cardiac surgery and infants with trisomy 18 and additionally to identify approaches used by cardiac surgeons in determining surgical candidates.

## **METHODS**

### **Study Participants**

Clinicians in the following specialties were eligible for participation: OBGYNs, MFMs, neonatologists, medical geneticists, genetic counselors, cardiologists, and cardiac surgeons. This study was approved by the Institutional Review Board of the University of Texas MD Anderson Cancer Center UTHealth Graduate School of Biomedical Sciences (HSC-MS-16-0454). Genetic counselors were recruited via a survey link electronically distributed to members of the National Society of Genetic Counselors listserv. Physicians were recruited through genetic counselors affiliated with fetal centers across the United States. Genetic counselors disseminated the survey

link by emails to the eligible physicians at their respective institutions. Additionally, physicians were recruited through electronic distribution of the survey link via membership of the North American Fetal Therapy Network. Lastly, physicians that were reached by the methods listed above were given approval to distribute the survey link to their colleagues in the eligible specialty that were not already captured by previously implemented data collection methods. The study consent was present at the beginning of the survey on Qualtrics in the form of a letter of invitation. Completion of the survey was considered consent. Specific recruitment dates varied by data collection method, with responses collected from August to December 2016.

### **Anonymous Survey**

The survey consisted of questions regarding demographics of the clinicians, general questions about knowledge of and experience with patients with trisomy 18, and clinicians' attitudes towards reasons against and for offering cardiac surgery for infants with trisomy 18. Cardiac surgeons were additionally asked questions about the types of heart defects on which they would perform surgery on infants with trisomy 18 and if the presence of additional anomalies would impact their decision to perform such surgery. Participants were asked to respond to the questions in this survey specifically for non-mosaic trisomy 18. The question formatting consisted of multiple choice, "agree" or "disagree," and Likert scale questions on a scale of 1 (strongly disagree) to 5 (strongly agree) including the option of "neutral." For the purpose of data analysis and throughout this paper, clinicians who indicated they "strongly disagree" or "disagree" with the statement have been grouped together and will be referred to as "disagreeing," while clinicians who indicated they "strongly agree" or "agree" with the statement will be referred to as "agreeing." Free text boxes were available for additional comments which were included to obtain exploratory data that may lead to hypothesis-building and future studies. A formal validated measure was not used as survey questions were uniquely



developed by the authors for the purpose of this study and were reviewed by clinicians in each of the specialties of interest.

### **Data Analysis**

Responses were managed using Qualtrics and were stored at the McGovern Medical School. STATA 13.1 statistical software was used for data analysis. Descriptive statistics were used to describe the results of all clinicians, while quantitative statistical comparisons were analyzed between the following clinician types: prenatal physicians (including OBGYNs and MFMs), postnatal physicians (including neonatologists, medical geneticists, cardiologists, and cardiac surgeons), and genetic counselors. This latter comparison was chosen based on the substantial number of genetic counselor respondents compared to other specialties to account for the difference in number of participants. Statistically significant relationships for Likert scale variables were determined by analyzing the three comparison groups using Kruskal Wallis tests and between two groups using Mann Whitney ranked sum tests. Categorical variables were compared using contingency tests (Fisher exact or Chi-square). A  $p$ -value of  $<0.05$  was considered statistically significant.

Free responses were individually reviewed and classified for common themes that were presented by the clinicians. These classifications were independently performed by two authors (MK and RC) and represented a degree of agreeability. Secondary qualitative assessments were made of these responses to identify themes and topics that were raised by clinicians.

### **RESULTS**

A total of 378 clinicians participated in this survey which included 253 genetic counselors, 72 MFMs, 22 medical geneticists, 14 neonatologists, 8 cardiologists, 6 cardiac surgeons, and 3 OBGYNs. Participants who completed only the demographic section of the

survey were excluded from data analysis. Response rate was difficult to determine due to the multiple methods of data collection and the independent discretion of the genetic counselors that were asked to disseminate the survey to physicians associated with their institution.

## **Demographics**

The majority of clinicians were female (86%), Non-Hispanic white (91%) working in university based hospital practices (58%) or non-university based hospital practices (29%). Forty-five percent of clinicians were between 25-34 years of age with ages ranging from 18-24 through 65 or older. The majority (69%) of clinicians reported they see 1-5 patients with trisomy 18 per year. Of the clinicians who indicated they see at least one patient with trisomy 18 on average per year, 50% reported they discussed the option of cardiac surgery with at least one of their patients, while 46% indicated they did not have the discussion with any of the patients with trisomy 18. Please see Table 1 below for additional demographic information.

**Table 1: Demographics of clinicians (n=378)**

Age (n=371)	n	(%)	Specialty (n=378)	n	(%)
18-24	20	(5)	Genetic counselors	253	(67)
25-34	168	(45)	Prenatal	149	(59)
35-44	84	(23)	Pediatrics	55	(22)
45-54	63	(17)	Prenatal/Pediatrics	36	(14)
55-64	27	(7)	Other (cancer, lab, industry, etc)	13	(5)
65 or older	9	(3)	Maternal fetal medicine specialists	72	(19)
			Medical geneticists	22	(6)
Gender (n=375)	n	(%)	Neonatologists	14	(4)
Female	323	(86)	Cardiologists	8	(2)
Male	52	(14)	Cardiac surgeons	6	(1)
			Congenital heart surgery	6	(100)
Ethnicity (n=378)	n	(%)	Obstetricians and gynecologists	3	(1)
Non-Hispanic white	345	(91)			
Asian	11	(3)	Years in Current Specialty (n=378)	n	(%)
African American	4	(1)	Less than 5 years	168	(45)
Other	18	(5)	5-10 years	72	(19)
			11-15 years	46	(12)
Region of the United States (n=370)	n	(%)	16-20 years	35	(9)
South	114	(31)	More than 20 years	57	(15)
Midwest	98	(27)			
West	75	(20)	Years since medical/genetic counseling degree (n=376)	n	(%)
Northeast	66	(18)	Less than 5 years	134	(36)
Other	17	(4)	5-10 years	86	(23)
			11-15 years	40	(10)
Setting of Practice (n=375)	n	(%)	16-20 years	35	(9)
University-based	218	(58)	More than 20 years	81	(22)
Non-university based	108	(29)			
Private practice	30	(8)	Patients seen (on avg/year) with dx of non-mosaic trisomy 18 (n=378)	n	(%)
Other	19	(5)	None	40	(11)
			1-5	262	(69)
			6-10	59	(16)
			11 or more	15	(4)
			Not sure	2	(0)
			Patients (on avg/year) with non-mosaic trisomy 18 with whom cardiac surgery was discussed (n=321)	n	(%)
			None	149	(46)
			1-5	156	(49)
			6-10	5	(2)
			11 or more	4	(1)
			Not sure	7	(2)

## General Knowledge and Attitudes Towards Trisomy 18

Sixty-nine percent of clinicians accurately answered that 5-10% of infants with trisomy 18 survive beyond one year when asked about the average postnatal lifespan. More prenatal physicians (36%) inaccurately recalled the average postnatal lifespan to be less than 1% survive beyond one year compared to postnatal physicians (32%) genetic counselors (23%). Nearly half of all clinicians ( $n=357$ , 48%) agreed that discussing the option of cardiac surgery is appropriate, while thirty percent of clinicians disagreed. When stratified by clinician type (prenatal physicians vs. postnatal physicians vs. genetic counselors), there was a significant trend ( $p<0.001$ ) where postnatal physicians were more likely to agree ( $n=48$ , 44%) compared to prenatal physicians ( $n=73$ , 29%) about the appropriateness of discussing the option of cardiac surgery. Fifty-nine percent of all clinicians ( $n=356$ ) agreed that the discussion of cardiac surgery is within their scope of practice. When asked if insurance companies should cover the cost of cardiac surgery, overall about a third each of all clinicians agreed (30%), disagreed (33%), or were neutral (37%). Prenatal physicians were statistically more likely to disagree about insurance coverage for surgery ( $n=73$ , 59%) than postnatal physicians or genetic counselors, 23% and 27% respectively ( $p<0.001$ ).

Clinicians were asked about their attitudes towards the following terms being used to describe individuals with trisomy 18: vegetative, incompatible with life, lethal anomaly, and life-limiting. Most clinicians disagreed with the use of vegetative ( $n=356$ , 68%), while across all specialties most clinicians agreed with the term life-limiting ( $n=357$ , 93%). When stratified by clinician type, more prenatal physicians agreed with use of the term vegetative ( $n=73$ , 38%) compared to postnatal physicians ( $n=48$ , 27%) and genetic counselors ( $n=235$ , 10%) although the differences were not statistically significant. Prenatal physicians were statistically more

likely to agree with use of the term “incompatible with life” ( $n=73$ , 52%) compared to postnatal physicians ( $n=48$ , 29%,) and genetic counselors ( $n=235$ , 32%) ( $p=0.026$ ).

### **General Questions Towards Cardiac Surgery for Infants with Trisomy 18**

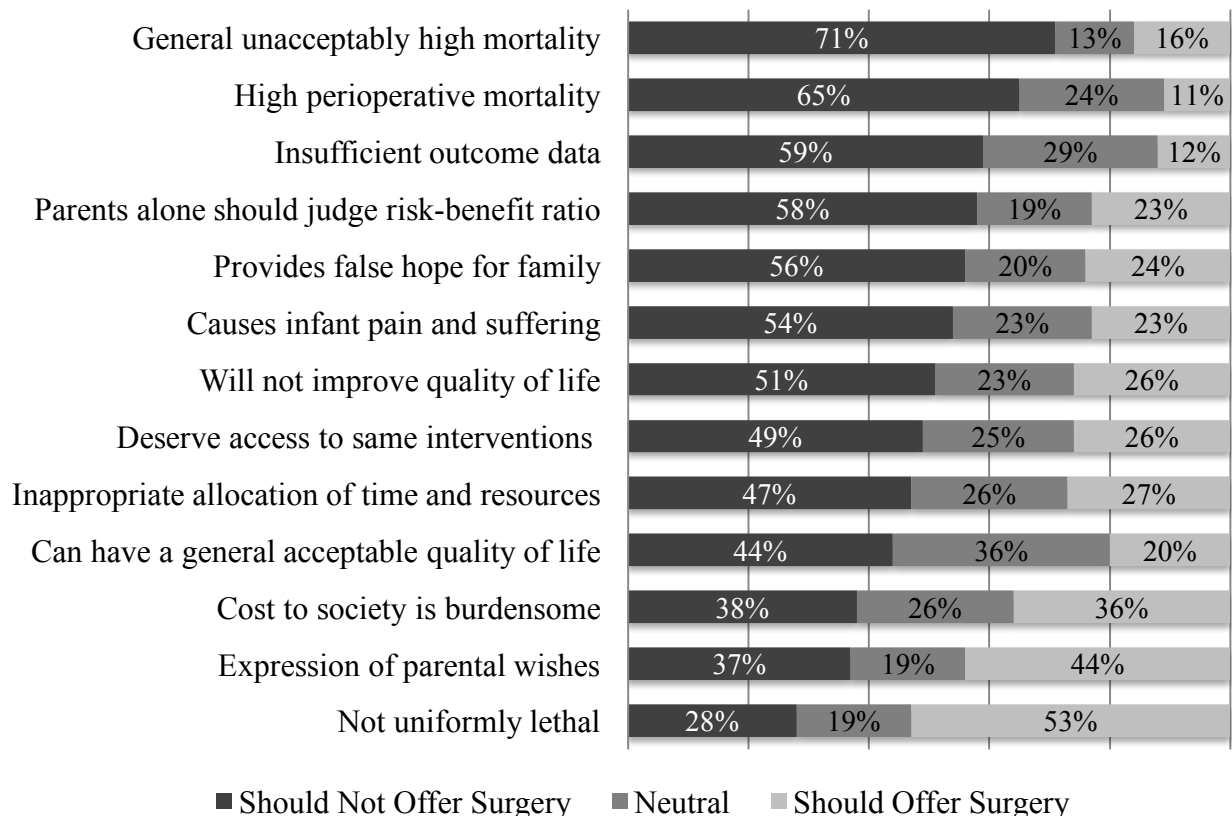
Clinicians were asked whether they agreed or disagreed with statements regarding the end benefit of cardiac surgery for infants with trisomy 18. Over half of all clinicians agreed with the following potential benefits: parental autonomy is respected ( $n=345$ , 91%), potential extension of time with their infant ( $n=344$ , 81%), and the potential for improved quality of life ( $n=339$ , 51%). Thirty-seven percent of clinicians ( $n=345$ ) felt there was “no end benefit” in performing cardiac surgery. When stratified by clinician type, prenatal physicians (58%) were more likely to agree that cardiac surgery has “no end benefit” than other clinician types ( $p<0.001$ ). Prenatal physicians were statistically more likely to disagree that cardiac surgery has the potential to extend the time with their infant (37%,  $p<0.001$ ) and could potentially improve the infant’s quality of life (68%,  $p=0.002$ ). With the option to select all that apply, clinicians ( $n=347$ ) indicated that first hand clinical experiences (64%), medical/genetic counseling school training (59%), discussions with colleagues (57%), and parental autonomy (42%) influence their recommendations towards cardiac surgery. Thirty percent ( $n=287$ ) of clinicians reported their current approach with patients includes discussing cardiac surgery if brought up by parents, emphasizing it may be an option, and providing a referral to cardiac surgery, while 28% ( $n=295$ ) indicated their current approach includes discussing if brought up by parents but emphasizing surgery is discouraged. Forty-six percent ( $n=347$ ) of clinicians indicated their approach has not changed over time meaning clinicians who have always discussed the option, still discuss, while clinicians who have not discussed the option, still do not discuss. The 54% of clinicians whose approach has changed over time indicated it was due to clinical experiences (21%), discussion with colleagues (21%), and new literature on the topic (12%). Of the formerly

mentioned 48% of clinicians ( $n=347$ ) who felt cardiac surgery is appropriate to discuss with patients, 74% indicated their approach would be to discuss surgery and/or refer the patient to cardiac surgery. Of the clinicians who felt the discussion of cardiac surgery was inappropriate (30%), 11% indicated they would still discuss surgery and/or refer the patient to cardiac surgery.

### Attitudes Regarding Considerations in Offering Cardiac Surgery

Over half of all clinicians ( $n=346-356$ ) agreed with the following reasons as justifications to not offer cardiac surgery for infants with trisomy 18: condition has a general unacceptably high mortality (71%), high perioperative mortality (65%), insufficient outcome data and on risks and benefits of surgery (59%), parents alone should judge risk-benefit ratio of surgery (58%), provides false hope for the family (56%), causes infant pain and suffering (54%), and surgery will not improve the infant's quality of life (51%) (Figure 1).

**Figure 1: Clinician attitudes towards considerations surrounding cardiac surgery for infants with trisomy 18 ( $n=346-356$ )**



When clinicians were asked about societal costs of cardiac surgery for these infants, 47% of clinicians agreed that surgery should not be offered due to surgery being an inappropriate allocation of the institution's time and resources and 38% agreed that the cost of surgery to society is burdensome as reasons not to offer cardiac surgery. Overall when stratified by clinician types, prenatal physicians tended to be more likely to indicate surgery should not be offered compared to postnatal physicians and genetic counselors, who tended to have more equal distributions between agreeing, disagreeing, and neutral (Table 2).

**Table 2: Comparison of attitudes towards considerations in offering cardiac surgery by clinician type (prenatal physicians ( $n=75$ ), postnatal physicians ( $n=50$ ), genetic counselors ( $n=253$ ))**

	Should Not Offer Surgery	Neutral	Should Offer Surgery
<b>Reasons Regarding Offering Cardiac Surgery</b>			
*General unacceptably high mortality ( $p<0.001$ )			
Prenatal physicians	85%	5%	10%
Postnatal physicians	54%	17%	29%
Genetic counselors	71%	14%	15%
*High perioperative mortality ( $p<0.001$ )			
Prenatal physicians	64%	32%	4%
Postnatal physicians	42%	31%	27%
Genetic counselors	69%	21%	10%
Insufficient outcome data ( $p=0.262$ )			
Prenatal physicians	50%	43%	7%
Postnatal physicians	54%	17%	29%
Genetic counselors	63%	26%	11%
Parents alone should judge risk-benefit ratio ( $p=0.319$ )			
Prenatal physicians	64%	13%	23%
Postnatal physicians	78%	7%	15%
Genetic counselors	52%	24%	24%
*Provides false hope for family ( $p<0.001$ )			
Prenatal physicians	67%	18%	15%
Postnatal physicians	61%	10%	29%
Genetic counselors	52%	22%	26%
Causes infant pain and suffering ( $p=0.086$ )			
Prenatal physicians	62%	20%	18%
Postnatal physicians	58%	19%	23%
Genetic counselors	51%	24%	25%
*Will not improve quality of life ( $p=0.021$ )			
Prenatal physicians	58%	27%	15%
Postnatal physicians	54%	19%	27%
Genetic counselors	48%	22%	30%

*Deserve access to same interventions ( $p<0.001$ )			
Prenatal physicians	71%	20%	9%
Postnatal physicians	67%	13%	20%
Genetic counselors	39%	29%	32%
*Inappropriate allocation of time and resources ( $p<0.001$ )			
Prenatal physicians	76%	13%	11%
Postnatal physicians	32%	33%	35%
Genetic counselors	42%	28%	30%
*Can have a general acceptable quality of life ( $p<0.001$ )			
Prenatal physicians	62%	34%	4%
Postnatal physicians	44%	26%	30%
Genetic counselors	39%	38%	23%
*Cost to society is burdensome ( $p<0.001$ )			
Prenatal physicians	68%	18%	14%
Postnatal physicians	28%	36%	36%
Genetic counselors	31%	26%	43%
*Expression of parental wishes ( $p=0.034$ )			
Prenatal physicians	57%	20%	23%
Postnatal physicians	59%	19%	22%
Genetic counselors	27%	18%	55%
*Condition is not uniformly lethal ( $p=0.007$ )			
Prenatal physicians	53%	17%	30%
Postnatal physicians	37%	26%	37%
Genetic counselors	19%	18%	63%

One exception was in regard to insufficient research on risks and benefits. Genetic counselors were more likely to agree (63%) than prenatal (50%) and postnatal physicians (42%) with insufficient outcome data as a reason to not offer cardiac surgery. The differences were statistically significant between prenatal physicians, postnatal physicians, and genetic counselors for all provided considerations regarding cardiac surgery with the exception of insufficient outcome data, the risks and benefits of surgery, parents alone should judge the risk-benefit of surgery, and surgery causes the infant pain and suffering. Please see Table 2 for additional information.

Fifty-three percent ( $n=347$ ) of clinicians across all specialties agreed that trisomy 18 not being uniformly lethal is a reason to offer cardiac surgery (Figure 1). This was the sole consideration on which the majority of all clinicians agreed in support of offering surgery. Of all clinicians, 44% agreed that surgery should be offered if parents express their wish to have “everything done” for their child. When stratified into clinician type, genetic counselors were



twice as likely to agree (55%) with surgery being offered due expression of parental wishes compared to prenatal and postnatal physicians, 23% and 22% respectively ( $p=0.034$ ). Overall 26% of clinicians felt surgery should be offered because infants with trisomy 18 deserve access to the same interventions as chromosomally typical infants compared to 49% who disagreed; further analysis revealed that genetic counselors were statistically more likely to agree (32%) with this statement as justification for offering surgery than prenatal and postnatal physicians (9% and 20% respectively) ( $p<0.001$ ). Twenty percent of clinicians agreed that individuals with trisomy 18 having an acceptable quality of life was a reason to offer cardiac surgery, while 36% were neutral. Postnatal physicians and genetic counselors were more likely to agree (30% and 23%) with this statement as a justification to offer surgery than prenatal physicians (4%) ( $p<0.001$ ).

### **Cardiac Surgeon Approaches to Determining Candidates for Cardiac Surgery**

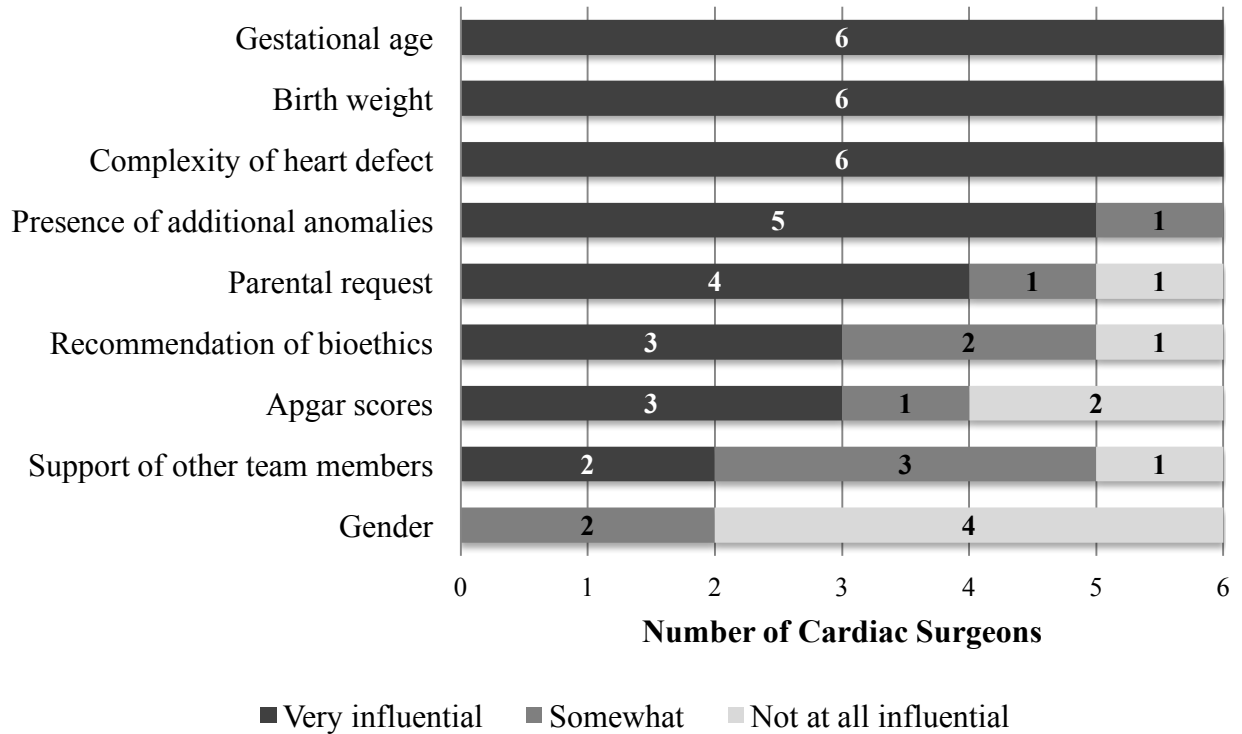
Four out of six cardiac surgeons reported they had performed cardiac surgery on at least one infant with trisomy 18; the two cardiac surgeons that had not performed surgery indicated they would be willing to do so. Most cardiac surgeons indicated they would be willing to perform surgery on an infant with trisomy 18 for the following heart defects: VSD (5/6), PDA (5/6), coarctation of the aorta (5/6), and ASD (4/6) while none of the cardiac surgeons indicated they would be willing to perform surgery on infants with trisomy 18 and hypoplastic left heart syndrome (Table 3).

**Table 3: Cardiac surgeons' willingness to perform surgery on infants with trisomy 18 depending on the type of heart defect and the presence of additional anomalies (n=6)**

Type of Heart Defect	Willing to Perform Surgery (n)
Ventricular septal defect	5
Patent ductus arteriosus	5
Coarctation of the aorta	5
Atrial septal defect	4
Tetralogy of fallot	3
Pulmonary stenosis	3
Atrioventricular septal defect	2
Transposition of the great arteries	1
Double outlet right ventricle	1
Hypoplastic left heart syndrome	0
Anomalies Present in Addition to Heart Defect	Willing to Perform Surgery (n)
Clubfoot	5
Polydactyly	5
Cleft lip +/- palate	4
Spina bifida	3
Omphalocele	2
Esophageal atresia	1
Diaphragmatic hernia	0

In an infant with trisomy 18 with a heart defect described to be of mild to moderate complexity, most cardiac surgeons were still willing to perform surgery in the presence of additional anomalies including clubfoot (5/6), polydactyly (5/6), and cleft lip with or without cleft palate (4/6). Fewer reported willingness to perform surgery as the severity of the anomaly increased, with no cardiac surgeons (0/6) willing to perform surgery with the additional finding of a diaphragmatic hernia. All cardiac surgeons selected gestational age, birth weight, the complexity of the heart defect, and presence of additional anomalies as influential factors in determining appropriate candidates for surgery. The gender of the infant was found to be the least influential factor in determining candidacy for surgery (Figure 2).

**Figure 2: Cardiac Surgeons' attitudes towards the influence of other factors in their willingness to perform cardiac surgery on infants with trisomy 18 (n=6)**



Half of cardiac surgeons (3/6) indicated their decision to perform cardiac surgery on infants with trisomy 18 is made on a “case by case basis” while the other half (3/6) indicated the decision is made at the discretion of the attending team.

### Free responses

Of the clinicians in our study, 29% left free responses (n=108). A total of 158 free responses were recorded, as many clinicians left more than one free response. A topic that was brought up most by clinicians (approximately 40%) in the free responses was that the appropriateness of offering cardiac surgery for an infant with trisomy 18 should depend on the clinical picture of the infant.

*“Decisions about intervention should be made on the individual child's situation, not a blanket decision based on chromosomal diagnosis.” – Medical geneticist*

*“I feel that the decision to pursue cardiac intervention for patients with [trisomy 18] is a very personal decision that should be made collaboratively with both the patient and the care team. If the patient is relatively stable and is healthy enough to undergo cardiac intervention without almost definite outcomes of death during surgery, the family should be offered intervention. The value of added days, weeks or years of life expectancy as well as the quality of a child's life should not be determined by care providers alone but together with the family.” - Neonatologist*

*“[Performing surgery] depends on the surgery. If it is "palliative" ... to relieve symptoms and/or [only] one surgery...then it might be fine. For complex lesions...surgery should not be offered.” – Cardiologist*

Another frequently encountered topic pertained to the parents being adequately informed of the risks and benefits of surgery before making a decision.

*“If extensive counseling is performed and the parents appear to understand the limitations of such care, and the care is available.. it may be appropriate to have this discussion.” – MFM*

*“Parents should be provided with factual information and have access to a counselor who can guide them through the process of making a decision that fits with what they want for their child.” – Medical geneticist*

*“I feel like a thorough discussion with the parents regarding why they wish for cardiac intervention is ESSENTIAL.” – Genetic counselor*

Many clinicians brought up the overall cost of surgery including societal burden and the emotional and financial cost to the family.

*“[Cardiac] surgery could diminish any quality time the parents could expect with these very disabled children for no real expectation of long term benefit.” – MFM*

*“Raising the unnecessary cost of medical care to society just because you can is a disservice to society.” – MFM*

*“What cardiac surgery does in many cases is to prolong the life in the hospital at the expense of the family.” – Medical geneticist*

Lastly, clinicians indicated that cardiac surgery may potentially improve the outcome of the infant with trisomy 18.

*“There may be some instances where palliative procedures reduce suffering but do not necessarily prolong life, which may be an acceptable intervention.” – MFM*

*“Many of the cardiac defects result in increased work of breathing which results in respiratory distress. Repairing these can alleviate some degree of suffering [for the infant]” – Cardiologist*

*“[Surgery] could optimize quality of life for the time the infant has available.” – Cardiac surgeon*

## DISCUSSION

The appropriateness of offering cardiac surgery to families of infants with trisomy 18 is undoubtedly complex and has been met with a wide range of opinions in the literature. Our study describes clinician attitudes surrounding this topic while further demonstrating the variability in opinions of various clinicians often involved in the care and counseling of these families. Our results suggest that nearly half of clinicians in our study feel it is appropriate to discuss the option of cardiac surgery with postnatal physicians and genetic counselors feeling it is more appropriate for this discussion to take place than prenatal physicians. Of clinicians who feel this discussion is appropriate, the vast majority are discussing the option of surgery and/or referring the patient to cardiac surgery for such a discussion to take place. This clinical approach of discussing cardiac surgery supports recent literature pointing to the fact that cardiac surgery for infants with trisomy 18 is occurring more frequently than previously reported<sup>36</sup>. Few clinicians who responded that the discussion of cardiac surgery is inappropriate still report discussing and/or referring their patients to cardiac surgery. Interestingly, a quarter of clinicians felt the discussion was appropriate, however indicated that they do not discuss the option of cardiac surgery. This suggests there may be barriers that clinicians experience regarding the discussion of cardiac surgery, however these potential barriers that may exist were not formally explored in our study. Several respondents stated lack of accessibility to willing surgeons in the free responses as further explanations for why the option is not offered to their patients; exploration of this and other barriers is warranted through formal study. Overall, our study provides evidence that there are clinicians across multiple sub-specialties who feel the discussion of cardiac surgery is appropriate and report actually having such discussions with families and referring them to cardiac surgery.

There is limited research in current literature examining clinician attitudes towards the use of a wide range of terms to describe individuals with trisomy 18. These terms range from less patient friendly descriptions such as vegetative, incompatible with life, and lethal anomaly to the more patient friendly term life-limiting, which were included based on literature regarding communicating with families about trisomy 18 as well as other severe conditions<sup>24, 39-41</sup>. While overall most clinicians disagreed with the less patient friendly terms (vegetative and incompatible with life) and agreed with the most patient friendly term (life-limiting), prenatal physicians were more likely to agree with the less sensitive terms when compared to postnatal physicians and genetic counselors.

One challenge families of infants with trisomy 18 face is the inconsistency between prenatal and postnatal counseling by their medical team. Our study shows evidence that prenatal physicians have significantly different perceptions of trisomy 18 compared to our other clinician groups. We found that prenatal physicians were more likely to agree with use of less patient friendly terms to describe the prognosis of trisomy 18 (specifically incompatible with life) and were slightly more likely to indicate infants with trisomy 18 have a shorter lifespan than current literature supports. Additionally, prenatal physicians were more likely to consider surgery to have no end benefit and less likely to consider surgery may have the potential to extend time with infant or improve the infant's quality of life. Overall, prenatal physicians reported less support of the discussion of the option of cardiac surgery for these infants compared to postnatal physicians and genetic counselors. While we cannot ascertain from our study the reason prenatal physicians responded more unfavorably towards trisomy 18 than postnatal physicians and genetic counselors, we can speculate based on the nature of the patients and care these clinicians provide in their respective specialties. For those working with families following a prenatal diagnosis, 72% of those pregnancies will result in miscarriage or stillbirth<sup>42</sup> thus the majority may feel the discussion of surgery is inappropriate and irrelevant to the majority of the

pregnancies they encounter due to the high percentage of prenatal and perinatal deaths. Conversely, postnatal physicians are more likely to encounter the 28% of infants with trisomy 18 who have survived delivery and potentially the neonatal period and thus may represent the less severely affected cases where potentially the discussion of cardiac surgery is more appropriate and relevant. These experiences of clinicians may in turn affect the perception of these clinicians towards trisomy 18 in general and regarding the appropriateness of discussing the option of cardiac surgery.

In our study, clinician attitudes were examined around common themes that have emerged in previous literature<sup>15-18, 24</sup>. These themes included ethical considerations such as access to interventions, the general high mortality of trisomy 18, potential for pain and suffering of infant during and post-surgery, high perioperative mortality of surgery, and providing false hope to the family, as well as other themes including societal costs, insufficient outcome data, issues surrounding quality of life, and parental autonomy. In general, our study provides evidence that there is clinician support of the discussion of the option cardiac surgery. However, many clinicians still expressed discomfort with offering cardiac when considering the lack of outcome data and reasons surrounding ethical principles such as nonmaleficence, beneficence, and justice. These findings support and further validate numerous studies<sup>15-17</sup> that have expressed hesitancy in performing or offering cardiac surgery for infants with trisomy 18 when considering ethical issues and insufficient outcome data. Clinicians indicating that ethical concerns surrounding offering surgery were justifications against offering surgery was unsurprising as ethical concerns surrounding this topic are undeniably an important and recurrent topic in discussions between clinicians and with families when deciding if cardiac surgery is appropriate<sup>24</sup>. Dissimilarly, several studies<sup>15, 29</sup> have pointed to the societal burden of performing cardiac surgery for these infants as a clear reason against offering surgery; however



more clinicians in our study felt surgery should still be offered or were neutral regarding societal burdens of cardiac surgery than felt societal burdens were a reason against offering surgery. There was also no consensus among clinicians when asked if insurance companies should cover the cost of surgery. Therefore, it may be that the potential burden to society that others have suggested is not uniformly felt by clinicians in our study as a reason not to offer surgery.

The consideration of trisomy 18 not being uniformly lethal was the sole reason upon which more than half of clinicians agreed cardiac surgery should be offered. This finding is consistent with a notable shift in the literature emphasizing that trisomy 18 should not be presented as a lethal anomaly in the counseling of families given the known survivability<sup>2, 40, 43</sup>. Previous studies<sup>32, 33</sup> have suggested that parental autonomy provides an impact regarding management decisions made by clinicians, however the results of our study demonstrated mixed feelings toward parental involvement. Over half of clinicians in this study disagreed or were neutral regarding expressed parental wishes as a reason to offer cardiac surgery, however, the great majority of clinicians in our study felt that an end benefit to performing surgery is that parental autonomy is respected. This implies that clinicians in our study may or may not feel that parental autonomy sway their decisions to offer cardiac surgery, but they did agree that parental autonomy had a place as a potential benefit of performing surgery.

Most clinicians “strongly disagreed” with parents alone judging the risk-benefit ratio of cardiac surgery as a reason to offer cardiac surgery than all other reasons provided. This was further illustrated by multiple free response comments expressing that allowing parents alone to weigh the risks and benefits of surgery takes away from the valuable medical expertise and experience clinicians provide. These findings support the “shared decision making approach” suggested in previous literature, which describes an approach to care that involves the values

and wishes of the families as well as the medical knowledge and expertise of clinicians of multiple subspecialties<sup>30</sup>.

Our study also aimed to describe cardiac surgeons' approaches to determining candidacy for cardiac surgery among infants with trisomy 18. Due to the small number of cardiac surgeons who participated in this survey, we are unable to draw conclusions but can make general comments on the responses received from the surgeons in our study. With regard to the heart defect complexity, as expected, more cardiac surgeons in our study were willing to perform surgical repair on mild to moderate complex heart defects such as VSDs, PDAs, and coarctations of the aorta, while less were willing to perform surgery for increasingly complex heart defects such as transposition of the great arteries and double outlet right ventricle and none were willing to perform surgery on the complex hypoplastic left heart syndrome. This is consistent with previous studies<sup>11, 19-23</sup> that have described repairs of congenital heart defects in infants with trisomy 18, suggesting that they are the heart defects most operated on of those reported. Cardiac surgeons were less likely to be willing to perform surgery in the presence of additional worsening anomalies such as esophageal atresia and congenital diaphragmatic hernia, which even when found in isolation have higher postoperative morbidity and mortality compared to other anomalies such as polydactyly and cleft lip with or without cleft palate<sup>44, 45</sup>. Cardiac surgeons indicated that other factors such as gestational age and birth weight were influential along with the complexity of the heart defect and presence of other anomalies when considering an infant for cardiac surgery. The specific aspects of gestational age and birth weight were not described; future studies may allow surgeons to expand upon this further with insights into their attitudes towards acceptable birth weights and gestational ages at time of delivery. Overall, these findings suggest cardiac surgeons are most willing to perform surgery on mild to moderate heart defects in the absence of additional anomalies or presence of

additional anomalies associated with lower morbidity rates. Further, our study found that all cardiac surgeons who responded have either performed surgery or are willing to perform surgery, demonstrating that the option exists.

Genetic counselors are often involved in both the pre- and postnatal discussions regarding the care and management for families with a diagnosis of trisomy 18. The overall findings of this study were that a greater majority of genetic counselors felt the discussion of cardiac surgery is appropriate compared to physicians. Expressed parental wishes and trisomy 18 not being uniformly lethal were more important considerations reported by genetic counselors in support of offering surgery, compared to physicians. These findings support basic tenants of genetic counseling regarding nondirective counseling, providing balanced perspectives of conditions, supporting patient autonomy and decision making, and advocating for families. Furthermore, genetic counselors have the skills to initiate psychosocially targeted conversations with families and they are often able to ascertain the family's values and wishes as to better understand the reasoning behind their pursuit of aggressive interventions like cardiac surgery for their infant. Ascertaining the family's values and wishes, advocating for patients and their family as well as placing an importance on patient autonomy highlights the valuable and unique role genetic counselors play as part of a multidisciplinary team regarding complex management decisions such as the pursuit of cardiac surgery<sup>46</sup>.

## **PRACTICE IMPLICATIONS**

Our study demonstrates the differing opinions among clinicians regarding the appropriateness of offering cardiac surgery. The difference is most notable when comparing prenatal physicians to postnatal physicians and genetic counselors. The differing opinions between clinicians overall and specifically with regard to prenatal physicians points to the importance of open communication among the specialties to ensure that providers are educated

on how their colleagues are approaching this option with patients. Families should be provided with balanced and consistent counseling on the decisions surrounding cardiac surgery to avoid misunderstanding and mistrust<sup>17</sup>.

While not ascertained in previous literature for comparisons, almost half of the clinicians in our study indicated that they feel the discussion of cardiac surgery is appropriate and approximately half of the clinicians self-reported that their approach to discussing the option of cardiac surgery has changed over time. This suggests that attitudes are not static towards surgical interventions for infants with trisomy 18 and that there is potential for approaches to continue to evolve over time. Moreover, all cardiac surgeons in our study were willing to perform surgery on infants with trisomy 18 depending on the clinical picture of the infant, which may contradict some clinicians' beliefs. While limitations exist with the data obtained by the cardiac surgeons in our study, understanding the willingness and conditions in which cardiac surgeons will perform surgery is another important aspect to this complex topic that further points to an evolving attitude.

The goal of this study was not to provide recommendations for uniform care of all infants with heart defects and trisomy 18, as an individualized approach to care of each patient is paramount. Results of this study may lead to a heightened appreciation for the complexity of this issue for clinicians who may perceive cardiac surgery as irrelevant or believe that the barrier to access surgeons who are willing to perform surgery is so great that it is simply not worth considering. Our findings support the notion of incorporating at least recognition of the option of cardiac surgery in the discussion of management of infants with trisomy 18, including an acknowledgment that this may not be available based on the clinical picture or other center-specific criteria, as well as giving families permission to not explore or choose this option.

Appropriate referrals can be provided if the discussion is beyond the clinician's scope of practice, knowledge, or comfort.

We hope the results of this study will be shared within and among multidisciplinary specialists involved in the care of infants with trisomy 18 to improve understanding of current practice and attitudes. By stimulating such discussions among clinicians, further education and informed attitudes regarding this topic among themselves and their peers will be accomplished. We appreciate it is unrealistic to believe clinicians will ever completely agree on offering surgery or not; however it is reasonable to expect clinicians to collaborate with one another in the care of families of infants with trisomy 18 in order to promote consistent patient care and open and honest discussions exploring families' goals and wishes.

## **STRENGTHS AND LIMITATIONS**

This study was able to describe the attitudes of both prenatal and postnatal clinicians surrounding their attitudes towards care of infants with trisomy 18. This is a strength of our study since many clinicians are involved in the care surrounding infants with trisomy 18 during the pre- and postnatal period, thus we were able to make comparisons. Previous literature has pointed to the importance for such examinations before further progress on this topic can be made<sup>35, 36, 38</sup>. Our study design also allowed for sampling attitudes of physicians throughout the country in the specialties of maternal fetal medicine and genetic counseling which aids to the applicability of these results.

The sampling of physicians through fetal centers may have led to attitudes mostly representative of physicians in medical centers with access to more cutting edge technology and colleagues who are more likely to be in an academic setting practicing standards of care based on current literature. Therefore, our physician population (excluding MFMs) is not

representative of physicians at large, but rather more likely representative of physicians in an academic setting.

Sample sizes for some of our physician groups were a limitation as well. While the postnatal physician group captured a wide spectrum of the physicians involved in the care of infants with trisomy 18 in the postnatal period, the prenatal physician group consisted mostly of MFMs ( $n=72$ ) and few OBGYNs ( $n=3$ ). Therefore, the results of this study and the attitudes of the prenatal physicians should be interpreted to be mostly representative of MFMs and cannot be extrapolated to the attitudes of OBGYNs. Our study does represent a broad sample of MFMs which is valuable since MFMs are important clinicians in high-risk pregnancies such as those diagnosed with trisomy 18. However, we cannot comment extensively on the attitudes of OBGYNs who, depending on the circumstance, may be the initial and possibly only contact for families when a diagnosis of trisomy 18 is suspected or confirmed. Therefore, this is a limitation of our study. Similarly, the six cardiac surgeons who responded to our survey practice either in Texas ( $n=4$ ) or Missouri ( $n=2$ ). Therefore, the attitudes of the cardiac surgeons in our study cannot be extrapolated to be representative of the attitudes and opinions of cardiac surgeons in general. This is, again, a limitation of our study as one of the aims was to comment further on the opinions of cardiac surgeons and the influential variables in determining surgical candidacy for infants with trisomy 18, however based on our small sample size, we are limited to sharing our findings and not drawing conclusions.

Another limitation that is common to survey research is selection bias. The clinicians who participated in our study may be those who feel most strongly about this topic and may not represent the average clinician. Additionally, although we have reported qualitative assessments of the free responses, it should be noted that our survey was not designed as a qualitative free response study. Therefore, it is possible the responses were biased by the questions preceding them.

Lastly, at times the term “cardiac intervention” was used in the survey which was intended to be synonymous with cardiac surgery, however upon closer consideration could have been interpreted as palliative surgical interventions, such as pulmonary artery banding, not exclusively surgical repair<sup>47</sup>. While most often the actual phrase “cardiac surgery” was used, the following questions used “cardiac intervention”: appropriateness to discuss the option, appropriateness for insurance companies to cover cost, discussion is within scope of practice, “end benefit” questions, factors that have influenced clinicians’ recommendations, and questions regarding clinicians’ approaches to such discussion. Overall, we do not feel this discrepancy in wording heavily impacted the results and conclusions drawn from our study.

## **FUTURE DIRECTIONS**

While our study was able to capture a variety of pre- and postnatal clinicians that are involved in care of these infants, the opinions of other clinicians such as pediatricians, nurses, and social workers would be a valuable addition to the literature in an effort to obtain inclusive data on the attitudes of the many clinicians involved to better understand the perspective of the different specialties. This would ultimately better serve families encountering this decision-making process in the future. Continued research is also needed on the cardiac conditions and influential variables impacting surgical treatment in a larger population of cardiac surgeons to better describe how these decisions are made. Finally, if current trends continue and more families are offered and pursue the option of surgery, longitudinal research should be done to assess these outcomes as well as the experiences of the families. This will provide necessary information to those clinicians still hesitant to broach this topic based on insufficient research on outcomes and will also provide better understanding of clinician and family interactions.

## APPENDIX

Q1 Age

- ☐ 18 - 24
- ☐ 25 - 34
- ☐ 35 - 44
- ☐ 45 - 54
- ☐ 55 - 64
- ☐ 65 - 74
- ☐ 75 or older

Q2 Gender

- ☐ Male
- ☐ Female

Q3 Race/Ethnicity

- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Pacific Islander
- ☐ Other

Q4 In what state do you currently practice?

*(select state from drop down menu)*

Q5 Setting of practice

- ☐ University based hospital practice
- ☐ Non-university hospital practice
- ☐ Private practice
- ☐ Other, please specify \_\_\_\_\_

Q6 How many years have you been in your current specialty?

- ☐ less than 5 years
- ☐ 5 to 10 years
- ☐ 11 to 15 years
- ☐ 16 to 20 years
- ☐ more than 20 years



Q7 What is your specialty?

- ☐ Obstetrics and Gynecology (skip to Q8)
- ☐ Maternal Fetal Medicine (skip to Q8)
- ☐ Neonatology (skip to Q23)
- ☐ Medical Genetics (skip to Q23)
- ☐ Genetic Counseling (skip to Q38)
- ☐ Cardiology (skip to Q23)
- ☐ Cardiothoracic surgery (skip to Q54)
- ☐ Other, please specify \_\_\_\_\_ (skip to Q8)

Q8 How many years since you have received your medical degree?

- ☐ less than 5 years
- ☐ 5 to 10 years
- ☐ 11 to 15 years
- ☐ 16 to 20 years
- ☐ more than 20 years

Q9 Please select from the choices provided your understanding of the postnatal lifespan of patients with non-mosaic trisomy 18:

- ☐ No infants survive beyond one year
- ☐ <1% survive beyond one year
- ☐ 5-10% survive beyond one year
- ☐ 20-25% survive beyond one year
- ☐ I do not know

Q10 How many patients with a prenatal diagnosis of trisomy 18, on average per year, have you participated in care for?

- ☐ None
- ☐ 1-5
- ☐ 6-10
- ☐ 11-15
- ☐ 16-20
- ☐ 21 or more
- ☐ Not sure

Q11 How many patients with a prenatal diagnosis of trisomy 18, on average per year, have you discussed cardiac intervention as a postnatal option?

- ☐ None
- ☐ 1-5
- ☐ 6-10
- ☐ 11-15
- ☐ 16-20
- ☐ 21 or more

☐ Not sure

The remaining questions are pertaining to your attitudes and beliefs regarding trisomy 18 and cardiac intervention. Please remember to consider each question in regards to a diagnosis of non-mosaic trisomy 18. Please click the arrow below to continue.

Q12 Please indicate for each of the following terms below whether you agree or disagree with the term being used to describe patients with trisomy 18.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Life-limiting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vegetative	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Incompatible with life	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lethal anomaly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q13 On a scale of "strongly disagree" to "strongly agree," please indicate your opinion on the following statements below.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
It is appropriate to counsel families with an infant with trisomy 18 and a cardiac defect about the option of cardiac intervention.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is appropriate for insurance companies to cover the cost of cardiac intervention for infants with trisomy 18.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discussing the option of cardiac intervention for infants with a prenatal diagnosis of trisomy 18 is within my scope of practice.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q14 The below reasons have been given for NOT providing cardiac surgery on infants with trisomy 18. On a scale of "strongly disagree" to "strongly agree," please indicate your feelings toward each statement.

Surgery should not be offered to infants with trisomy 18 because...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Trisomy 18 is associated with unacceptably high mortality.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is an inappropriate allocation of the institution's time and resources.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because the perioperative mortality is unacceptably high in these infants.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surgery results in prolonging short-term life but does not produce a cure or affect long-term survival.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The cost to society for the infants to undergo surgery is burdensome.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surgery will not improve the quality of the infant's life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There is insufficient research done examining the risks and benefits to the infant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surgery causes the infant pain and suffering.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It provides false hope for the family.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q15 Additional reasons you feel cardiac surgery SHOULD NOT be performed on an infant with trisomy 18, if any.  
(open response text box)

Q16 The below reasons have been given in SUPPORT of providing cardiac surgery on infants with trisomy 18. On a scale of "strongly disagree" to "strongly agree," please indicate your feelings toward each statement.

Surgery should be offered to infants with trisomy 18...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
If the parents express their desire to have "everything done" for their child.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because the infant deserves the opportunity for the same interventions offered to other chromosomally normal infants with congenital heart defects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because surgery may improve the infant's quality of life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because trisomy 18 is not uniformly lethal.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because infants with trisomy 18 can have an acceptable quality of life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because parent(s) alone should judge risk-benefit ratio for surgery.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q17 Additional reasons you feel cardiac surgery SHOULD be performed on an infant with trisomy 18, if any.  
(open response text box)

Q18 If cardiac surgery is performed on infants with trisomy 18, I feel the end benefit of this intervention is:

	Disagree	Agree
No end benefit	<input type="radio"/>	<input type="radio"/>
Parental wishes/autonomy are honored	<input type="radio"/>	<input type="radio"/>
Potential for extended time with infant	<input type="radio"/>	<input type="radio"/>
Potential for improved quality of life	<input type="radio"/>	<input type="radio"/>
Other, please specify	<input type="radio"/>	<input type="radio"/>

Q19 Which factors have influenced your recommendations towards cardiac intervention for infants with trisomy 18? (check all that apply)

- ☐ Medical school training
- ☐ First hand clinical experience
- ☐ Discussion with colleagues
- ☐ Parental autonomy
- ☐ Other, please specify \_\_\_\_\_

Q20 Please describe your approach to discussing the option of cardiac intervention for infants with trisomy 18.

- ☐ I do not discuss the option of cardiac intervention.
- ☐ I will discuss it if brought up by the parents, but I emphasize intervention is discouraged.
- ☐ I will discuss it if brought up by the parents, emphasize it may be an option, but do not refer to cardiac surgery.
- ☐ I will discuss it if brought up by the parents, emphasize it may be an option, and refer to cardiac surgery.
- ☐ I discuss it in all cases regardless if brought up by parents.
- ☐ Other, please specify \_\_\_\_\_

Q21 If your approach to discussing cardiac intervention has changed over time, what has influenced this? (check all that apply)

- ☐ My approach has not changed.
- ☐ New literature on this topic
- ☐ Discussions with my colleagues
- ☐ First hand clinical experiences
- ☐ Other, please specify \_\_\_\_\_

Q22 Any additional comments you have on this subject of trisomy 18 and cardiac intervention would be helpful.

*(open response text box)*

END OF SURVEY

Q23 How many years since you have received your medical degree?

- ☐ less than 5 years
- ☐ 5 to 10 years
- ☐ 11 to 15 years
- ☐ 16 to 20 years
- ☐ more than 20 years

Q24 Please select from the choices provided your understanding of the postnatal lifespan of patients with non-mosaic trisomy 18:

- ☐ No infants survive beyond one year
- ☐ <1% survive beyond one year
- ☐ 5-10% survive beyond one year
- ☐ 20-25% survive beyond one year
- ☐ I do not know

Q25 How many patients with a diagnosis of trisomy 18, on average per year, have you participated in care for?

- ☐ None
- ☐ 1-5
- ☐ 6-10
- ☐ 11-15
- ☐ 16-20
- ☐ 21 or more
- ☐ Not sure

Q26 How many patients with a diagnosis of trisomy 18, on average per year, have you discussed cardiac intervention as a postnatal option?

- ☐ None
- ☐ 1-5
- ☐ 6-10
- ☐ 11-15
- ☐ 16-20
- ☐ 21 or more
- ☐ Not sure

The remaining questions are pertaining to your attitudes and beliefs regarding trisomy 18 and cardiac intervention. Please remember to consider each question in regards to a diagnosis of non-mosaic trisomy 18. Please click the arrow below to continue.

Q27 Please indicate for each of the following terms below whether you agree or disagree with the term being used to describe patients with trisomy 18.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Life-limiting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vegetative	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Incompatible with life	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lethal anomaly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q28 On a scale of "strongly disagree" to "strongly agree," please indicate your opinion on the following statements below.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
It is appropriate to counsel families with an infant with trisomy 18 and a cardiac defect about the option of cardiac intervention.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is appropriate for insurance companies to cover the cost of cardiac intervention for infants with trisomy 18.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discussing the option of cardiac intervention for infants with a diagnosis of trisomy 18 is within my scope of practice.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q29 The below responses have been given for NOT providing cardiac surgery on infants with trisomy 18. On a scale to "strongly disagree" to "strongly agree", please indicate your feelings toward each statement.

Surgery should not be offered to infants with trisomy 18 because...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Trisomy 18 is associated with unacceptably high mortality.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is an inappropriate allocation of the institution's time and resources.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because the perioperative mortality is unacceptably high in these infants.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surgery results in prolonging short-term life but does not produce a cure or affect long-term survival.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The cost to society for the infants to undergo surgery is burdensome.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surgery will not improve the quality of the infant's life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There is insufficient research done examining the risks and benefits to the infant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surgery causes the infant pain and suffering.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

It provides false hope for the family.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
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Q30 Additional reasons you feel cardiac surgery SHOULD NOT be performed on an infant with trisomy 18, if any.  
(open response text box)

Q31 The below reasons have been given in SUPPORT of providing cardiac surgery on infants with trisomy 18. On a scale of "strongly disagree" to "strongly agree," please indicate your feelings toward each statement.

Surgery should be offered to infants with trisomy 18...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
If the parents express their desire to have "everything done" for their child.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because the infant deserves the opportunity for the same interventions offered to other chromosomally normal infants with congenital heart defects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because trisomy 18 is not uniformly lethal.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because infants can have an acceptable quality of life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because parent(s) alone should judge risk-benefit ratio for surgery.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q32 Additional reasons you feel cardiac surgery SHOULD be performed on an infant with trisomy 18, if any.  
(open response text box)

Q33 If cardiac surgery is performed on infants with trisomy 18, I feel the end benefit of this intervention is:

	Disagree	Agree
No end benefit	<input type="radio"/>	<input type="radio"/>
Parental wishes/autonomy are honored	<input type="radio"/>	<input type="radio"/>
Potential for extended time with infant	<input type="radio"/>	<input type="radio"/>
Potential for improved quality of life	<input type="radio"/>	<input type="radio"/>
Other, please specify	<input type="radio"/>	<input type="radio"/>



Q34 Which factors have influenced your recommendations towards cardiac intervention for infants with trisomy 18? (check all that apply)

- ☐ Medical school training
- ☐ First hand clinical experience
- ☐ Discussion with colleagues
- ☐ Parental autonomy
- ☐ Other, please specify \_\_\_\_\_

Q35 Please describe your approach to discussing the option of cardiac intervention for infants with trisomy 18.

- ☐ I do not discuss the option of cardiac intervention.
- ☐ I will discuss it if brought up by the parents, but I emphasize intervention is discouraged.
- ☐ I will discuss it if brought up by the parents, emphasize it may be an option, but do not refer to cardiac surgery.
- ☐ I will discuss it if brought up by the parents, emphasize it may be an option, and refer to cardiac surgery.
- ☐ I discuss it in all cases regardless if brought up by the parents.
- ☐ Other, please specify \_\_\_\_\_

Q36 If your approach to discussing the option of cardiac intervention has changed over time, what has influenced this? (check all that apply)

- ☐ My approach has not changed.
- ☐ New literature on this topic
- ☐ Discussions with my colleagues
- ☐ First hand clinical experiences
- ☐ Other, please specify \_\_\_\_\_

Q37 Any additional comments you have on this subject of trisomy 18 and cardiac intervention would be helpful.

*(open response text box)*

END OF SURVEY

Q38 How many years since you have received your master's in genetic counseling?

- ☐ less than 5 years
- ☐ 5 to 10 years
- ☐ 11 to 15 years
- ☐ 16 to 20 years
- ☐ more than 20 years

Q39 Please select all that apply regarding your current subspecialty in genetic counseling.

- ☐ Preconception/Prenatal
- ☐ Pediatrics/Medical Genetics
- ☐ Other, please specify \_\_\_\_\_

Q40 Please select from the choices provided your understanding of the postnatal lifespan of patients with non-mosaic trisomy 18:

- ☐ No infants survive beyond one year
- ☐ <1% survive beyond one year
- ☐ 5-10% survive beyond one year
- ☐ 20-25% survive beyond one year
- ☐ I do not know

Q41 How many patients with a prenatal diagnosis of trisomy 18, on average per year, have you participated in care for?

- ☐ None
- ☐ 1-5
- ☐ 6-10
- ☐ 11-15
- ☐ 16-20
- ☐ 21 or more
- ☐ Not sure

Q42 How many patients with a prenatal diagnosis of trisomy 18, on average per year, have you discussed cardiac intervention as a postnatal option?

- ☐ None
- ☐ 1-5
- ☐ 6-10
- ☐ 11-15
- ☐ 16-20
- ☐ 21 or more
- ☐ Not sure

The remaining questions are pertaining to your attitudes and beliefs regarding trisomy 18 and cardiac intervention. Please remember to consider each question in regards to a diagnosis of non-mosaic trisomy 18. Please click the arrow below to continue.

Q43 Please indicate for each of the following terms below whether you agree or disagree with the term being used to describe patients with trisomy 18.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Life-limiting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vegetative	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Incompatible with life	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lethal anomaly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q44 On a scale of "strongly disagree" to "strongly agree," please indicate your opinion on the following statements below.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
It is appropriate to counsel families with an infant with trisomy 18 and a cardiac defect about the option of cardiac intervention.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is appropriate for insurance companies to cover the cost of cardiac intervention for infants with trisomy 18.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discussing the option of cardiac intervention for infants with a prenatal diagnosis of trisomy 18 is within my scope of practice.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q45 The below reasons have been given for NOT providing cardiac surgery on infants with trisomy 18. On a scale of "strongly disagree" to "strongly agree," please indicate your feelings toward each statement.

Surgery should not be offered to infants with trisomy 18 because...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Trisomy 18 is associated with unacceptably high mortality.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is an inappropriate allocation of the institution's time and resources.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because the perioperative mortality is unacceptably high in these infants.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The cost to society for the infants to undergo surgery is burdensome.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surgery will not improve the quality of the infant's life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There is insufficient research done examining the risks and benefits to the infant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surgery causes the infant pain and suffering.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It provides false hope for the family.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q46 Additional reasons you feel cardiac surgery SHOULD NOT be performed on an infant with trisomy 18, if any.  
(open response text box)

Q47 The below reasons have been given in SUPPORT of providing cardiac surgery on infants with trisomy 18. On a scale of "strongly disagree" to "strongly agree," please indicate your feelings toward each statement.

Surgery should be offered to infants with trisomy 18...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
If the parents express their desire to have "everything done" for their child.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because the infant deserves the opportunity for the same interventions offered to other chromosomally normal infants with congenital heart defects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because trisomy 18 is not uniformly lethal.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because infants with trisomy 18 can have an acceptable quality of life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because parent(s) alone should judge risk-benefit ratio for surgery.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q48 Additional reasons you feel cardiac surgery SHOULD be performed on an infant with trisomy 18, if any.  
(open response text box)

Q49 If cardiac surgery is performed on infants with trisomy 18, I feel the end benefit of this intervention is:

	Disagree	Agree
No end benefit	<input type="radio"/>	<input type="radio"/>
Parental wishes/autonomy are honored	<input type="radio"/>	<input type="radio"/>
Potential for extended time with infant	<input type="radio"/>	<input type="radio"/>
Potential for improved quality of life	<input type="radio"/>	<input type="radio"/>
Other, please specify	<input type="radio"/>	<input type="radio"/>

Q50 Which factors have influenced your recommendations towards cardiac intervention for infants with trisomy 18? (check all that apply)

- ☐ Genetic counseling school training
- ☐ First hand clinical experience
- ☐ Discussion with colleagues
- ☐ Parental autonomy
- ☐ Other, please specify \_\_\_\_\_

Q51 Please describe your approach to discussing the option of cardiac intervention for infants with trisomy 18.

- ☐ I do not discuss the option of cardiac intervention.
- ☐ I will discuss it if brought up by the parents, but I emphasize intervention is discouraged.
- ☐ I will discuss it if brought up by the parents, emphasize it may be an option, but do not refer to cardiac surgery.
- ☐ I will discuss it if brought up by the parents, emphasize it may be an option, and refer to cardiac surgery.
- ☐ I discuss it in all cases regardless if brought up by parents.
- ☐ Other, please specify \_\_\_\_\_

Q53 Any additional comments you have on this subject of trisomy 18 and cardiac intervention would be helpful.

*(open response text box)*

END OF SURVEY

Q54 Please select all that apply regarding your subspecialty in cardiothoracic surgery.

- ☐ Adult cardiac surgery
- ☐ Thoracic surgery
- ☐ Congenital heart surgery
- ☐ Other, please specify \_\_\_\_\_

Q55 Please select from the choices provided your understanding of the postnatal lifespan of patients with non-mosaic trisomy 18:

- ☐ No infants survive beyond one year
- ☐ <1% survive beyond one year
- ☐ 5-10% survive beyond one year
- ☐ 20-25% survive beyond one year
- ☐ I do not know

Q56 How many patients with a diagnosis of trisomy 18, on average per year, have you participated in care for?

- ☐ None
- ☐ 1-5
- ☐ 6-10
- ☐ 11-15
- ☐ 16-20

- ☐ 21 or more
- ☐ Not sure

Q57 Of the patients with a diagnosis of trisomy 18 that you have participated in care for, on average per year, how many have undergone cardiac surgery on average per year?

- ☐ None
- ☐ 1-5
- ☐ 6-10
- ☐ 11-15
- ☐ 16-20
- ☐ 21 or more
- ☐ Not sure

Q58 Most patients with trisomy 18 for whom I provide consultation are:

- ☐ Referred by their doctor
- ☐ Self-referred
- ☐ Other, please specify \_\_\_\_\_

Q59 Most patients with trisomy 18 for whom I provide consultation are:

- ☐ Currently pregnant
- ☐ Postnatal with a prenatal diagnosis of trisomy 18
- ☐ Postnatal with a postnatal diagnosis of trisomy 18
- ☐ Other, please specify \_\_\_\_\_

The remaining questions are pertaining to your attitudes and beliefs regarding trisomy 18 and cardiac intervention. Please remember to consider each question in regards to a diagnosis of non-mosaic trisomy 18. Please click the arrow below to continue.

Q60 Please indicate for each of the following terms below whether you agree or disagree with the term being used to describe patients with trisomy 18.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Life-limiting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vegetative	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Incompatible with life	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lethal anomaly	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q61 On a scale of "strongly disagree" to "strongly agree," please indicate your opinion on the following statements below.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
It is appropriate to counsel families	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

with an infant with trisomy 18 and a cardiac defect about the option of cardiac intervention.					
It is appropriate for insurance companies to cover the cost of cardiac intervention for infants with trisomy 18.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Discussing the option of cardiac intervention for infants with a diagnosis of trisomy 18 is within my scope of practice.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q62 The below reasons have been given for NOT providing cardiac surgery on infants with trisomy 18. On a scale of "strongly disagree" to "strongly agree," please indicate your feelings toward each statement.

Surgery should not be offered to infants with trisomy 18 because...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Trisomy 18 is associated with unacceptably high mortality.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
It is an inappropriate allocation of the institution's time and resources.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The perioperative mortality is unacceptably high in these infants.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The cost to society for the infants to undergo surgery is burdensome.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surgery will not improve the quality of the infant's life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
There is insufficient research done examining the risks and benefits to the infant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Q Surgery causes the infant pain and suffering.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6					
3 Surgery provides false hope for the family.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A					

Additional reasons you feel cardiac surgery SHOULD NOT be performed on an infant with trisomy 18, if any.  
(open response text box)

Q64 The below reasons have been given in SUPPORT of providing cardiac surgery on infants with trisomy 18. On a scale of "strongly disagree" to "strongly agree," please indicate your feelings toward each statement.

Surgery should be offered to infants with trisomy 18...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
If the parents express their desire to have "everything done" for their child.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because the infant deserves the opportunity for the same interventions offered to other chromosomally normal infants with congenital heart defects.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because trisomy 18 is not uniformly lethal.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because infants can have an acceptable quality of life.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Because parent(s) alone should judge risk-benefit ratio for surgery.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q65 Additional reasons you feel cardiac surgery SHOULD be performed on an infant with trisomy 18, if any.  
(open response text box)

Q66 If cardiac surgery is performed on infants with trisomy 18, I feel the end benefit of this intervention is:

	Disagree	Agree
There is no end benefit	<input type="radio"/>	<input type="radio"/>
Parental wishes/autonomy are honored	<input type="radio"/>	<input type="radio"/>
Potential for extended time with infant	<input type="radio"/>	<input type="radio"/>
Potential for improved quality of life	<input type="radio"/>	<input type="radio"/>
Other, please specify	<input type="radio"/>	<input type="radio"/>



Q67 How is your decision made whether or not to perform cardiac intervention for infants with trisomy 18? (check all that apply)

- ☐ I never perform cardiac intervention for infants with trisomy 18.
- ☐ I perform cardiac intervention for all infants with trisomy 18.
- ☐ I make the decision on a case-by-case basis.
- ☐ The decision is made at the discretion of the attending team.
- ☐ There is a defined protocol at my institution that I abide by.
- ☐ Other, please specify \_\_\_\_\_

Q68 If your approach to performing cardiac intervention to infants with trisomy 18 has changed over time, what has influenced this? (check all that apply)

- ☐ My approach has not changed.
- ☐ New literature on this topic
- ☐ Discussions with my colleagues
- ☐ First hand clinical experiences
- ☐ Other, please specify \_\_\_\_\_

Q69 Please rank the following factors that have influenced your approach towards cardiac intervention for infants with trisomy 18  
(1 most influential to 4 least influential)

- \_\_\_\_\_ Medical school training
- \_\_\_\_\_ First hand clinical experience
- \_\_\_\_\_ Discussion with colleagues
- \_\_\_\_\_ Parental autonomy

Q70 Have you performed cardiac surgery on an infant with trisomy 18?

- ☐ Yes (If yes go to Q73)
- ☐ No (If no go to Q71)

Q71 Would you ever consider performing cardiac surgery on an infant with trisomy 18?

- ☐ Yes (If yes go to Q73)
- ☐ No (If no go to Q72)

Q72 Please expand on your reasoning behind never considering performing cardiac surgery on an infant with trisomy 18.

(open text box)

END OF SURVEY

Q73 Please indicate which heart defects for infants with trisomy 18 you would operate on, in the absence of additional congenital defects:

	Yes	No
Atrial Septal Defect	<input type="radio"/>	<input type="radio"/>
Ventricular Septal Defect	<input type="radio"/>	<input type="radio"/>
Patent Ductus Arteriosus	<input type="radio"/>	<input type="radio"/>
Coarctation of the Aorta	<input type="radio"/>	<input type="radio"/>
Tetralogy of Fallot	<input type="radio"/>	<input type="radio"/>
Atrioventricular Septal Defect	<input type="radio"/>	<input type="radio"/>
Hypoplastic Left Heart	<input type="radio"/>	<input type="radio"/>
Double Outlet Right Ventricle	<input type="radio"/>	<input type="radio"/>
Pulmonary Stenosis	<input type="radio"/>	<input type="radio"/>
Transposition of the Great Arteries	<input type="radio"/>	<input type="radio"/>
Other, please specify	<input type="radio"/>	<input type="radio"/>

Q74 Please indicate on a scale of "not at all influential" to "very influential" which of the following factors influence your decision when determining if an infant with trisomy 18 is a good surgical candidate for cardiac surgery.

	Not at all influential	Somewhat influential	Very influential
Gender	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gestational age	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Birth weight	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Apgar scores of infant	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Presence of additional anomalies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Complexity of heart defect	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Parental request	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Support of other healthcare team members	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Recommendation of bioethics committee	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other, please specify	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q75 In an infant with trisomy 18 with a heart defect present of mild to moderate complexity, the additional presence of which of the below birth defects would preclude an infant from surgery:

	Would still perform surgery	Would no longer perform surgery
Cleft lip/palate	<input type="radio"/>	<input type="radio"/>
Omphalocele	<input type="radio"/>	<input type="radio"/>
Esophageal atresia with or without tracheoesophageal fistula	<input type="radio"/>	<input type="radio"/>
Club foot	<input type="radio"/>	<input type="radio"/>
Congenital diaphragmatic hernia	<input type="radio"/>	<input type="radio"/>
Spina bifida	<input type="radio"/>	<input type="radio"/>
Polydactyly	<input type="radio"/>	<input type="radio"/>

Q76 Any additional comments on trisomy 18 and cardiac intervention would be helpful.  
*(open response text box)*  
 END OF SURVEY

## BIBLIOGRAPHY

1. Embleton ND, Wyllie JP, Wright MJ, Burn J, Hunter S. Natural history of trisomy 18. *Archives of disease in childhood Fetal and neonatal edition*. 1996;75(1):F38-41.
2. Cereda A, Carey JC. The trisomy 18 syndrome. *Orphanet journal of rare diseases*. 2012;7:81.
3. Rasmussen SA, Wong LY, Yang Q, May KM, Friedman JM. Population-based analyses of mortality in trisomy 13 and trisomy 18. *Pediatrics*. 2003;111(4 Pt 1):777-784.
4. Meyer RE, Liu G, Gilboa SM, Ethen MK, Aylsworth AS, Powell CM, Flood TJ, Mai CT, Wang Y, Canfield MA. Survival of children with trisomy 13 and trisomy 18: A multi-state population-based study. *American journal of medical genetics Part A*. 2015.
5. Saldarriaga W, Rengifo-Miranda H, Ramirez-Cheyne J. [Trisomy 18 syndrome: A case report]. *Revista chilena de pediatria*. 2015.
6. Kelly M, Robinson BW, Moore JW. Trisomy 18 in a 20-year-old woman. *American journal of medical genetics*. 2002;112(4):397-399.
7. Shanske AL. Trisomy 18 in a second 20-year-old woman. *American journal of medical genetics Part A*. 2006;140(9):966-967.
8. Tucker ME, Garringer HJ, Weaver DD. Phenotypic spectrum of mosaic trisomy 18: two new patients, a literature review, and counseling issues. *American journal of medical genetics Part A*. 2007;143a(5):505-517.
9. Baty BJ, Blackburn BL, Carey JC. Natural history of trisomy 18 and trisomy 13: I. Growth, physical assessment, medical histories, survival, and recurrence risk. *American journal of medical genetics*. 1994;49(2):175-188.
10. Van Dyke DC, Allen M. Clinical management considerations in long-term survivors with trisomy 18. *Pediatrics*. 1990;85(5):753-759.
11. Bruns DA, Martinez A. An analysis of cardiac defects and surgical interventions in 84 cases with full trisomy 18. *American journal of medical genetics Part A*. 2015.

12. Kavarana MN. Cardiac Surgical Repair Should Be Offered to Infants with Trisomy 18, Interrupted Aortic Arch and Ventricular Septal Defect. *The Journal of law, medicine & ethics : a journal of the American Society of Law, Medicine & Ethics*. 2016;44(2):283-285.
  
13. Imai K, Uchiyama A, Okamura T, Ago M, Suenaga H, Sugita E, Ono H, Shuri K, Masumoto K, Totsu S, Nakanishi H, Kusuda S. Differences in mortality and morbidity according to gestational ages and birth weights in infants with trisomy 18. *American journal of medical genetics Part A*. 2015;167a(11):2610-2617.
  
14. Paris JJ, Weiss AH, Soifer S. Ethical issues in the use of life-prolonging interventions for an infant with trisomy 18. *Journal of perinatology : official journal of the California Perinatal Association*. 1992;12(4):366-368.
  
15. Graham EM. Infants with Trisomy 18 and Complex Congenital Heart Defects Should Not Undergo Open Heart Surgery. *The Journal of law, medicine & ethics : a journal of the American Society of Law, Medicine & Ethics*. 2016;44(2):286-291.
  
16. Boss RD, Holmes KW, Althaus J, Rushton CH, McNee H, McNee T. Trisomy 18 and complex congenital heart disease: seeking the threshold benefit. *Pediatrics*. 2013;132(1):161-165.
  
17. Janvier A, Farlow B, Wilfond BS. The experience of families with children with trisomy 13 and 18 in social networks. *Pediatrics*. 2012;130(2):293-298.
  
18. Janvier A, Watkins A. Medical interventions for children with trisomy 13 and trisomy 18: what is the value of a short disabled life? *Acta paediatrica (Oslo, Norway : 1992)*. 2013;102(12):1112-1117.
  
19. Kaneko Y, Kobayashi J, Yamamoto Y, Yoda H, Kanetaka Y, Nakajima Y, Endo D, Tsuchiya K, Sato H, Kawakami T. Intensive cardiac management in patients with trisomy 13 or trisomy 18. *American journal of medical genetics Part A*. 2008;146a(11):1372-1380.
  
20. Kobayashi J, Kaneko Y, Yamamoto Y, Yoda H, Tsuchiya K. Radical surgery for a ventricular septal defect associated with trisomy 18. *General thoracic and cardiovascular surgery*. 2010;58(5):223-227.
  
21. Maeda J, Yamagishi H, Furutani Y, Kamisago M, Waragai T, Oana S, Kajino H, Matsuura H, Mori K, Matsuoka R, Nakanishi T. The impact of cardiac surgery in patients with trisomy 18 and trisomy 13 in Japan. *American journal of medical genetics Part A*. 2011;155a(11):2641-2646.

22. Yamagishi H. Cardiovascular surgery for congenital heart disease associated with trisomy 18. *General thoracic and cardiovascular surgery*. 2010;58(5):217-219.
23. Graham EM, Bradley SM, Shirali GS, Hills CB, Atz AM. Effectiveness of cardiac surgery in trisomies 13 and 18 (from the Pediatric Cardiac Care Consortium). *The American journal of cardiology*. 2004;93(6):801-803.
24. Janvier A, Farlow B, Barrington K. Cardiac surgery for children with trisomies 13 and 18: Where are we now? *Seminars in perinatology*. 2016.
25. Costello JP, Weiderhold A, Louis C, Shaughnessy C, Peer SM, Zurakowski D, Jonas RA, Nath DS. A contemporary, single-institutional experience of surgical versus expectant management of congenital heart disease in trisomy 13 and 18 patients. *Pediatric cardiology*. 2015;36(5):987-992.
26. Kaneko Y, Kobayashi J, Achiwa I, Yoda H, Tsuchiya K, Nakajima Y, Endo D, Sato H, Kawakami T. Cardiac surgery in patients with trisomy 18. *Pediatric cardiology*. 2009;30(6):729-734.
27. Muneuchi J, Yamamoto J, Takahashi Y, Watanabe M, Yuge T, Ohno T, Imoto Y, Sese A, Joo K. Outcomes of cardiac surgery in trisomy 18 patients. *Cardiology in the young*. 2011;21(2):209-215.
28. Carey JC. Perspectives on the care and management of infants with trisomy 18 and trisomy 13: striving for balance. *Current opinion in pediatrics*. 2012;24(6):672-678.
29. Janvier A, Okah F, Farlow B, Lantos JD. An infant with trisomy 18 and a ventricular septal defect. *Pediatrics*. 2011;127(4):754-759.
30. Andrews SE, Downey AG, Showalter DS, Fitzgerald H, Showalter VP, Carey JC, Hulac P. Shared decision making and the pathways approach in the prenatal and postnatal management of the trisomy 13 and trisomy 18 syndromes. *American journal of medical genetics Part C, Seminars in medical genetics*. 2016;172(3):257-263.
31. Wingate JR, Adachi I, Fenton K, Janvier A, Farlow B, Mossad EB. Case 14--2014: Tetralogy of Fallot with severe cyanosis in an infant with trisomy 18: ethical dilemmas in the perioperative period. *Journal of cardiothoracic and vascular anesthesia*. 2014;28(6):1677-1685.
32. McGraw MP, Perlman JM. Attitudes of neonatologists toward delivery room management of confirmed trisomy 18: potential factors influencing a changing dynamic. *Pediatrics*. 2008;121(6):1106-1110.

33. Jacobs AP, Subramaniam A, Tang Y, Philips JB, 3rd, Biggio JR, Edwards RK, Robin NH. Trisomy 18: A survey of opinions, attitudes, and practices of neonatologists. *American journal of medical genetics Part A*. 2016;170(10):2638-2643.
34. Wilkinson DJ, de Crespigny L, Lees C, Savulescu J, Thiele P, Tran T, Watkins A. Perinatal management of trisomy 18: a survey of obstetricians in Australia, New Zealand and the UK. *Prenatal diagnosis*. 2014;34(1):42-49.
35. Heuser CC, Eller AG, Byrne JL. Survey of physicians' approach to severe fetal anomalies. *Journal of medical ethics*. 2012;38(7):391-395.
36. Yates AR, Hoffman TM, Shepherd E, Boettner B, McBride KL. Pediatric sub-specialist controversies in the treatment of congenital heart disease in trisomy 13 or 18. *Journal of genetic counseling*. 2011;20(5):495-509.
37. Young AA, Simpson C, Warren AE. Practices and Attitudes of Canadian Cardiologists Caring for Patients With Trisomy 18. *The Canadian journal of cardiology*. 2017;33(4):548-551.
38. Hurley EH, Krishnan S, Parton LA, Dozor AJ. Differences in perspective on prognosis and treatment of children with trisomy 18. *American journal of medical genetics Part A*. 2014;164a(10):2551-2556.
39. Guon J, Wilfond BS, Farlow B, Brazg T, Janvier A. Our children are not a diagnosis: the experience of parents who continue their pregnancy after a prenatal diagnosis of trisomy 13 or 18. *American journal of medical genetics Part A*. 2014;164a(2):308-318.
40. Koogler TK, Wilfond BS, Ross LF. Lethal language, lethal decisions. *The Hastings Center report*. 2003;33(2):37-41.
41. Wilkinson D, de Crespigny L, Xafis V. Ethical language and decision-making for prenatally diagnosed lethal malformations. *Seminars in fetal & neonatal medicine*. 2014;19(5):306-311.
42. Morris JK, Savva GM. The risk of fetal loss following a prenatal diagnosis of trisomy 13 or trisomy 18. *American journal of medical genetics Part A*. 2008;146a(7):827-832.
43. 2005 American Heart Association (AHA) guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiovascular care (ECC) of pediatric and neonatal patients: pediatric advanced life support. *Pediatrics*. 2006;117(5):e1005-1028.

44. Wynn J, Krishnan U, Aspelund G, Zhang Y, Duong J, Stolar CJ, Hahn E, Pietsch J, Chung D, Moore D, Austin E, Mychaliska G, Gajarski R, Foong YL, Michelfelder E, Potolka D, Bucher B, Warner B, Grady M, Azarow K, Fletcher SE, Kutty S, Delaney J, Crombleholme T, Rosenzweig E, Chung W, Arkovitz MS. Outcomes of congenital diaphragmatic hernia in the modern era of management. *The Journal of pediatrics*. 2013;163(1):114-119.e111.
45. Lal DR, Gadepalli SK, Downard CD, Ostlie DJ, Minneci PC, Swedler RM, Chelius T, Cassidy L, Rapp CT, Deans KJ, Fallat ME, Finnell SM, Helmrath MA, Hirschl RB, Kabre RS, Leys CM, Mak G, Raque J, Rescorla FJ, Saito JM, St Peter SD, von Allmen D, Warner BW, Sato TT. Perioperative management and outcomes of esophageal atresia and tracheoesophageal fistula. *Journal of pediatric surgery*. 2016.
46. Benkendorf JL, Callanan NP, Grobstein R, Schmerler S, FitzGerald KT. An explication of the National Society of Genetic Counselors (NSGC) code of ethics. *Journal of genetic counseling*. 1992;1(1):31-39.
47. Yuan SM, Jing H. Palliative procedures for congenital heart defects. *Archives of cardiovascular diseases*. 2009;102(6-7):549-557.



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