Genetic Counselors' Approach To Postmortem Genetic Testing After Sudden Death: An Exploratory Study

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ABSTRACT

A significant portion of sudden death cases result from an underlying genetic etiology, which may be determined through postmortem genetic testing. The National Association of Medical Examiners (NAME) recommends that an appropriate postmortem sample is saved on all sudden death cases under the age of 40. Genetic counselors (GCs) play an important role in this process by working with medical examiners and coroners (ME/Cs) to recommend and interpret specific testing and to guide family members. A survey sent to the National Society of Genetic Counselors was designed and implemented to learn more about the experiences of genetic counselors who had considered or ordered postmortem genetic testing. Results showed that cardiovascular GCs were significantly more willing to recommend genetic testing in younger age decedents (ages 10, 18, 30, 40, and 50) compared to other specialty GCs ($p < 0.05$, Chi-square). Thirty-seven percent (7 of 19) of GCs reported insurance covering some portion of genetic testing. Participants also reported highest success for DNA extractions with fresh and frozen blood, reinforcing NAME recommendations for appropriate sample collection for postmortem genetic testing. Overall, participating GCs demonstrated a very good understanding for the appropriate use of postmortem genetic testing and did identify suspected barriers of cost and lack of insurance coverage as deterrents. With the rapid decrease in costs for diagnostic genetic testing, ME/C awareness of NAME recommendations for sample collection and storage remain important to facilitate postmortem genetic testing. *Acad Forensic Pathol.* 2018 8(3): 738-751

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KEYWORDS

Forensic pathology, Sudden death, Genetic counseling, Postmortem genetic testing, Autopsy

INFORMATION

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INTRODUCTION

Sudden cardiac death (SCD) is defined as the sudden, unexpected loss of heart function in an individual, with death occurring less than one hour after the onset of symptoms if witnessed, or if unwitnessed, the decedent had been seen alive and well within 24 hours of death (1, 2). For younger individuals who are affected by SCD, a significant genetic contribution has been described (3, 4). At least 40% of SCD in individuals under 40 years of age are attributed to genetic causes (3, 5).

To determine if a sudden death victim had an underlying genetic cause, postmortem genetic testing can be performed to screen for gene mutations. For cases in which the initial autopsy was negative, postmortem genetic testing yields a diagnosis in 25-35% of cases (6-8). The importance of postmortem genetic testing is reinforced by multiple associations, including the Heart Rhythm Society, the European Heart Rhythm Association, the Office of the Chief Coroner of Ontario, and the National Heart Foundation of New Zealand (5, 9, 10). The National Association of Medical Examiners (NAME) also detailed recommendations for sample collection in 2013, including saving a postmortem sample on all sudden death cases under the age of 40 (11).

Identifying a genetic diagnosis in a decedent may have important implications for family members and permit genetic testing in surviving relatives to determine increased risk for sudden death. If genetic testing of family members results in a confirmed diagnosis, early medical management and life saving treatment options can help affected individuals avoid a similar fate (8). However, postmortem genetic testing can be hampered due to a lack of sample or lack of uptake of recommendations. The cost of postmortem genetic testing has also been perceived as a significant barrier. Currently, there is limited coverage by most third party payers for postmortem genetic testing, so surviving family members (or in selected cases, medical examiners and coroners) are responsible for paying for the cost out of pocket (12-14).

As healthcare professionals with Master's degrees and with specialized training in medical genetics, genetic counselors (GCs) are available to help navigate the complex process of postmortem genetic testing for both families and healthcare providers. Genetic counselors have become increasingly involved in cardiovascular genetic services and practice guidelines recommend, including utilizing a GC in cases of sudden death (12, 15-17). Genetic counselors have an essential role in which they can provide expertise and counsel families to aid in their understanding of test results and management recommendations. However, there is little description of the motivations and knowledge base of GCs and their specific role in trying to identify a genetic cause of sudden death. This exploratory study aimed to learn more about the experiences of GCs who have considered or ordered postmortem genetic testing to gain more insight into their understanding of such testing and the process they undertake during the investigation.

METHODS

To recruit participants for the study, an email invitation was sent to full members of the National Society of Genetic Counselors (NSGC), the primary professional membership organization for GCs and other healthcare professionals with interests in genetic counseling. Respondents were asked to confirm their status as GCs with full membership and to identify as someone who previously considered or ordered postmortem genetic testing in sudden death cases. All responses were voluntary and anonymous. Participants had the opportunity to enter a raffle for one of ten \$20 Visa gift cards and thus provided identifiers for this purpose. The study was approved by the Northwestern University Institutional Review Board (STU201845).

After initial aims had been defined, a literature search and a search of the NSGC cardiovascular listserve archive were conducted to ensure that the survey covered topics of interest to the genetic counseling community. The survey consisted of 29 questions, however skip logic was used to direct participants to appropriate questions based on their previous answer choices.

Statistical analysis was conducted using IBM SPSS software, version 23. Responses for all questions were first summarized using frequency distributions. Comparisons were performed for several questions based on number of years in practice, number of postmortem genetic testing cases, and primary specialty area. These response categories were collapsed into fewer categories for data analysis and in order to facilitate interpretation.

Overall, group comparisons were performed using Pearson Chi-square tests, Fisher's exact tests, and Mann-Whitney U tests. Pearson Chi-square tests and Fischer's exact tests were used for nominal data, and the Mann-Whitney U test was used to analyze 5-point Likert scale questions. Statistical significance was defined as a p -value equal to or less than 0.05.

RESULTS

Study Population

A link to the online survey was emailed to the NSGC membership, which is composed of 2450 full members. In total, there were 87 participants who accessed the survey between December 1, 2015 and January 21, 2016. Ten individuals answered that they had not previously considered or ordered postmortem genetic testing, and one individual skipped this question. Therefore, these 11 participants were removed and the final sample size was 76 individuals, with an official response rate of 3.1%.

Demographics

The majority of participants were early in their genetic counseling careers, with 67.4% of participants having five or fewer years of experience (**Table 1**). The most common primary specialty area, defined as the main subject of their practice, was cardiovascular (42.9%), but other specialties, including prenatal, pediatrics, cancer, adult, and laboratory, were also represented in the data set. Approximately half (45.8%) of the participants worked at a university medical center, while the remainder were employed in other settings, including public hospitals, private hospitals, and diagnostic lab-

oratories. The majority of respondents worked in an urban setting (77.1%).

For the 21 participants who identified as cardiovascular GCs, the majority had five or less years of experience (71.4%) and were members of the NSGC cardiovascular special interest group (95.2%) (**Table 2**). The NSGC cardiovascular special interest group serves as a resource for GCs in cardiology by providing a forum for webinars, peer guidance, and active discussion.

Postmortem Genetic Testing Cases

The number of postmortem genetic testing cases that each GC had experienced was queried. More than half of the respondents (57.9%) reported having experience with one to five cases. For the remaining participants, 19.7% had experience with six to ten cases, 6.6% reported experience with 11-15 cases or more than 20 cases each, and 9.2% reported not having any experience with postmortem genetic testing cases. Upon further comparison, we found that participants who had worked on one to five cases were more likely to have less experience (five years or less) compared to participants who worked on more than five cases ($p = 0.037$).

Cardiovascular GCs were compared with other specialty GCs to ascertain any differences in willingness to send samples for postmortem genetic testing and questioning whether age of the decedent was more likely to prompt genetic testing. We found that cardiovascular GCs were significantly more likely to send genetic testing from younger decedents (10, 18, 30, 40, and 50 years of age) with negative autopsy findings ($p < 0.05$).

Types of Postmortem Samples Used

Fresh blood and frozen blood were reported as the most common types of postmortem samples. In addition, fresh blood and frozen blood had the highest number of successful DNA extractions, but blood spot cards, frozen liver, and frozen heart tissue were also reported to have successful DNA extractions (**Figure 1**).

Table 1: Demographics of Genetic Counselors

Demographics	(n)	%
Years Practicing as a Genetic Counselor		
Under 2 years	12	24.5
2-5 years	21	42.9
6-10 years	6	12.2
11-20 years	7	14.3
Over 20 years	3	6.1
Total	49	100.0
Primary Specialty Area		
Cardiovascular	21	42.9
Prenatal	6	12.2
Pediatrics	9	18.4
Cancer	5	10.2
Adult	2	4.1
Laboratory	4	8.2
Other	2	4.1
Total	49	100.0
Current Work Setting		
University medical center	22	45.8
Public hospital or medical facility	12	25
Private hospital or medical facility	9	18.8
Diagnostic laboratory	3	6.3
Other	2	4.2
Total	48	100.0
Type of Community that Practice is Located In		
Suburban	7	14.6
Urban	37	77.1
Rural	2	4.2
Unknown or decline to state	2	4.2
Total	48	100.0

Participants reported extraction of postmortem DNA from a variety of blood tubes with lavender ethylenediaminetetraacetic acid (EDTA) blood tubes as the most commonly used tube type and having the highest

number of successful extractions. However, this data demonstrates that extraction attempts with other types of blood tubes had limited success (**Figure 2**).

Table 2: Demographic Information for Cardiovascular Genetic Counselors

Demographics	(n)	%
Years Practicing as a Cardiovascular Genetic Counselor		
Under 2 years	7	33.3
2-5 years	8	38.1
6-10 years	4	19.0
11-20 years	2	9.5
Over 20 years	0	0.0
Member of the National Society of Genetic Counselors Cardiovascular Special Interest Group		
Yes	20	95.2
No	1	4.8

Figure 1: Successful DNA extraction from postmortem sample types, n = 49.

Figure 2: DNA extraction results from various types of blood tubes, n = 49.

Insurance: Coverage and Barriers

The majority of participants ($n=26$; 51.0%) had not attempted to use the decedent's third party payer to pay for postmortem genetic testing. However, 35.3% ($n=18$) of participants did report attempting to obtain coverage through the decedent's insurance. For the individuals who had never attempted to use the deceased individual's insurance to cover postmortem testing, the most common reason was that "patient's family was willing to pay out of pocket" ($n=13$), and the second most common reason was that they "did not think insurance would cover" ($n=12$). The results are summarized in **Figure 3**.

An open response question allowed participants to list reasons why postmortem genetic testing was not attempted in situations in which testing was not performed (**Table 3**). The most common response from participants was that there was no sample or they were unable to obtain a sample ($n=17$; 39.5%), and the second most common response was cost ($n=14$; 32.6%). Other responses included family declined, lack of insurance coverage, and inappropriate testing sample.

Insurance Coverage

An open-ended question regarding the percentage of times that insurance had paid for postmortem genet-

Why have you never attempted to use insurance to cover the cost of postmortem genetic testing? Mark all that apply.

Figure 3: Reasons that genetic counselors never attempted to use insurance to cover the cost of postmortem genetic testing, $n = 25$.

ic testing, including partial payment, found that most participants (n=11) responded with 0%, but a few participants (n=5) report some success with insurance coverage of postmortem genetic testing. Participants who reported successful coverage had 20% to 100% of cases covered by insurance. The results are listed in **Table 4**.

Personal Opinions Regarding the Postmortem Genetic Testing Process

The thoughts and opinions of GCs who had participated in the postmortem genetic testing process were assessed using a 5-point Likert scale (**Figure 4**). Genetic counselors were asked if their experiences with post-

Table 3: Reasons For Not Performing Postmortem Genetic Testing

In Your Experience, for the Times When Clinical Or Diagnostic Postmortem Genetic Testing Was Not Performed, Why Was the Testing Not Performed?	(n=43)
No sample/unable to obtain a sample	17
Cost/too expensive	14
Family declined	8
Lack of insurance coverage	8
Sample collected, but not appropriate for testing	6
Quality of DNA not sufficient for testing	3
Decedent did not meet recommendations for testing	2
Too complicated/lack of knowledge	2

Table 4: Percent of Cases In Which An Insurance Company Has Paid For Postmortem Genetic Testing

In Your Experience, How Often Has Insurance Paid (Even Partial Payment) for Postmortem Genetic Testing in Sudden Cardiac Death Cases?	(n=19)
0%	11
10%	0
20%	1
30%	1
40%	0
50%	1
60%	0
70%	1
80%	0
90%	0
100%	1
Coroner's system, provincial insurance, or government paid	2
Limited experience but poor coverage overall	1

mortem genetic testing had discouraged them from pursuing postmortem genetic testing in the future, and the majority of participants indicated that they disagreed or strongly disagreed that their experiences had discouraged them from pursuing postmortem genetic testing in the future (67.4%). Genetic counselors were also asked about their role to educate medical examiners and coroners (ME/Cs) and other medical providers about the process of saving samples for postmortem genetic testing, and 83.7% of participants strongly agreed or agreed that it was an important role.

When comparing cardiovascular GCs with those of other specialties, it was found that cardiovascular GCs were less likely to agree that their experiences with postmortem genetic testing had discouraged them from pursuing postmortem genetic testing for future patients ($p = 0.002$), and cardiovascular GCs were more likely to agree that GCs have an important role to educate ME/Cs and other medical providers about the process of saving samples for postmortem genetic testing ($p = 0.001$).

Knowledge and Education Regarding Postmortem Genetic Testing

When participants were asked about knowledge regarding sample collection and retention recommendations made by NAME, responses were split with 55.1% ($n=27$) of individuals stating that they were aware of the recommendations and 44.9% ($n=22$) who were not aware. With regards to the NAME recommendations, it was found that GCs with five or less years of experience were less likely to be aware of NAME recommendations for sample collection and retention, as compared to participants practicing for over five years ($p = 0.015$). In addition, participants who had worked on one to five cases were more likely to have decreased awareness of the NAME recommendations for sample collection and retention ($p = 0.005$).

Rate how you feel about the following statements:

Figure 4: Opinions of genetic counselors regarding postmortem genetic testing.

DISCUSSION

To date, GCs have never collectively been queried on postmortem genetic testing. This knowledge can provide understanding of GCs' methods and thoughts during the postmortem genetic testing process.

Sample Types and Successful DNA Extraction

Participants were asked about the types of samples they had used for postmortem genetic testing and if DNA extraction was successful on those sample types. Fresh blood and frozen blood in lavender EDTA tubes were the most common types of postmortem samples used by participants and led to the highest rates of successful DNA extraction, although frozen liver and frozen heart tissue also had some success. This corresponds with recommendations from NAME regarding an appropriate type of sample to save for DNA banking and genetic testing (11). The National Society of Genetic Counselors also recommends saving 5-10 mL of blood in an EDTA tube for genetic testing (18). In contrast, tissue samples that were formalin-fixed did not have high rates of successful DNA extraction in the cohort, which is consistent with evidence found in a past study that showed formalin-fixed samples are unreliable for postmortem genetic testing in cases of sudden unexplained death (19).

In addition, participants had been able to use blood spot cards for successful DNA extraction, but details on the size of the panel or complexity of testing were not available through this survey. At the time of our survey, few genetic testing companies would attempt blood spot cards as a potential sample for postmortem genetic testing. However, more genetic testing companies now will attempt blood spot cards but are not able to report on success or failure rates. This survey reinforces that successful DNA extraction is possible through blood spot cards, and may provide additional support for blood spot cards to be used for postmortem genetic testing, especially in cases when other samples are not available. Using a blood spot card as a sample source should be verified with the lab performing testing prior to submission. Use of blood spot cards may limit the number of genes that can

successfully be tested. The NAME position paper recommends saving 5-10mL of blood in lavender EDTA tubes for postmortem genetic testing (11).

The success rates of DNA extraction were previously reported from four different laboratories (13). It was reported that fresh or frozen blood had a success rate of 93% (152/164), which is similar to the success rate reported in this study (88.6%; 39/44). However, participants reported their success through recall, therefore the reported success rates may be related to participants' perceptions of success, rather than actual rates of success.

Barriers to Postmortem Genetic Testing

Insurance Coverage

This study found that half of the participants (51.0%) had not attempted to use the decedent's insurance to cover postmortem genetic testing. Of the participants who had not attempted to use the decedent's insurance to cover testing cost, 48% stated that an attempt was not made because they did not think insurance would cover the cost of testing. It seems to be true that insurance does not always cover testing, as evidenced by results from this study, where 57.9% of individuals stated that insurance has paid for testing in 0% of their cases. Statements in published articles have also mentioned that insurance companies generally do not cover postmortem genetic testing costs (11, 12). However, a few participants reported success with insurance coverage, including partial payment, of postmortem genetic testing. Participants who had been successful reported that 20-100% of their postmortem genetic testing cases had been covered by insurance. In addition, Kane and Triedman published a case regarding a family with Long QT syndrome and hypertrophic cardiomyopathy where coverage of postmortem genetic testing was initially denied by insurance but subsequently covered after further discussion (14). This case, along with the data from this study, lends support that insurance coverage of postmortem genetic testing is possible, despite common belief. As a result, it is certainly worthwhile for GCs to attempt insurance coverage for future cases of sudden death

and to begin to set a precedent with insurance companies with the importance of such testing. In addition, as family cardiac screening is recommended for autopsy confirmed cardiac death cases (20), should a family member be identified with a cardiac condition through screening, genetic testing can then be initiated in the alive affected family member who does have active insurance. Then, the postmortem sample can be used as confirmation should a pathogenic or variant of uncertain significance be found in the living affected family member.

Reasons For Not Pursuing Postmortem Genetic Testing

When participants were asked why postmortem genetic testing was not performed in certain cases of sudden death, the most common response provided by participants was that no sample was available or a sample was unable to be obtained (39.5%). This finding reinforces the importance of following sample collection recommendations set forth by organizations such as NAME and NSGC. When a sample is not saved, the chance for postmortem genetic testing to determine cause of death and to identify potential at risk family members is lost. Interestingly, 18.6% of participants stated that postmortem genetic testing was not pursued because family members declined testing. One other participant stated that genetic testing was desired by 2nd and 3rd degree relatives, but 1st degree relatives of the decedent did not authorize testing. While it may be important to identify risks to any surviving family members, it is also important to recognize that family members may not choose to pursue genetic testing due to personal reasons. As highlighted by the response from one participant, informed consent should be obtained from the next of kin if this is required for genetic testing to be performed; however, if genetic testing is performed by the ME/C as part of the death investigation, then informed consent is not required. Genetic counselors are uniquely skilled to explain the benefits and limitations of genetic testing to surviving family members and to navigate the complexities of the informed consent process. Publications have highlighted the importance of GCs to provide comprehensive services to families with a history of cardiomyop-

athies and young SCD, such as educating families and promoting informed choices (3, 16, 21). The data from this survey reinforces that GCs have an important role by supporting and working with families during the postmortem genetic testing process.

Medical Examiners in the Postmortem Genetic Testing Process

The National Association of Medical Examiner's 2013 position paper was released to establish recommendations for the collection and storage of postmortem samples so that genetic testing can be pursued after sudden death. These recommendations were written in collaboration with GCs, with the goal of facilitating postmortem genetic testing and identifying at risk family members.

When participants were asked if they believed that GCs have an important role to educate ME/Cs and other medical providers about the process of saving samples for postmortem genetic testing, 83.7% of participants strongly agreed or agreed. Further analysis showed that cardiovascular GCs were more likely to agree with this statement than GCs from other specialties. It is helpful to learn that many GCs are willing to take on the duty of providing education to ME/Cs regarding sample collection and storage for facilitation of postmortem genetic testing. Although the 2013 NAME position paper provides guidelines for retaining samples for postmortem testing, different laboratories also have specifications for postmortem testing and advances in this area may lead to additional recommendations regarding postmortem samples. Understanding GCs' perceptions of how ME/Cs could benefit from additional education would be useful to guide resources on incorporating sample collection recommendations into more of ME/Cs' practice.

Study Limitations

Limitations in this study include the small sample size, however this was expected, as postmortem genetic testing is still a relatively new field. Furthermore, most of our participants are relatively inexperienced, as they had only practiced as a GC for five years or

fewer. Therefore, these findings are difficult to generalize and would likely be unrepresentative of the NSGC as a whole. Responses from our participants were based on self-report and were not confirmed with documentation or medical reports. Questions required participants to recall information if they did not have a case tracking system in place.

Opportunities for Further Research

This exploratory study of GCs' approach to the postmortem genetic testing process after sudden death has provided different avenues for future research. Future studies may focus on interviewing GCs individually in order to gain case-specific information regarding postmortem genetic testing in sudden death cases, include outcomes (such as types of molecular results) of postmortem genetic testing cases, and differences in the use of a clinical lab versus a research lab for testing. In this study, it was found that cost and insurance coverage were frequently cited as barriers to ordering postmortem genetic testing. However, some participants also stated that they were able to obtain insurance coverage for postmortem genetic testing. As a result, further research can explore if there are specific strategies or techniques that can aid in insurance coverage, or whether governmental insurance has helped with the cost of postmortem genetic testing. Finally, given that postmortem genetic testing is an emerging field, we hope that future studies will be able to survey more participants to gain a more in-depth understanding regarding GCs and postmortem genetic testing.

CONCLUSION

Genetic counselors were asked to share their experiences, approaches, and thoughts regarding the postmortem genetic testing process after sudden death. We found that the majority of GCs did not think their past experiences with postmortem genetic testing would discourage them from pursuing future testing, although proper sample collection, cost, and insurance coverage are major challenges present in the testing process. A few GCs reported success with obtaining insurance coverage for postmortem genetic testing, which is encouraging for future postmortem genetic

testing cases.

The data from this study also highlights that GCs' reports of postmortem samples with the most successful DNA extractions correspond with recommendations from NAME regarding appropriate types of samples to save for DNA banking and genetic testing.

Further research can help define specific strategies that GCs use during the postmortem genetic testing process, especially in areas such as insurance coverage of ordered tests. However, it remains critical that ME/Cs are aware of NAME recommendations for sample collection and storage, including the collection of 5-10 mL of blood at autopsy for sudden death cases under the age of 40, so that postmortem genetic testing can be facilitated and at risk individuals can be identified.

REFERENCES

- 1) Zipes DP, Wellens HJ. Sudden cardiac death. *Circulation*. 1998 Nov 24; 98(21):2334-51. PMID: 9826323. <https://doi.org/10.1161/01.cir.98.21.2334>.
- 2) Deo R, Albert CM. Epidemiology and genetics of sudden cardiac death. *Circulation*. 2012 Jan 31; 125(4):620-37. PMID: 22294707. PMCID: PMC3399522. <https://doi.org/10.1161/CIRCULATIONAHA.111.023838>.
- 3) MacLeod H, Demo E, Honeywell C, Rutberg J. Genetic counselors: an important resource for families following a young sudden cardiac death. *Acad Forensic Pathol*. 2013 Jun; 3(2):183-90. <https://doi.org/10.23907/2013.023>.
- 4) Stojanovska J, Garg A, Patel S, et al. Congenital and hereditary causes of sudden cardiac death in young adults: diagnosis, differential diagnosis, and risk stratification. *Radiographics*. 2013 Nov-Dec; 33(7):1977-2001. PMID: 24224591. <https://doi.org/10.1148/rg.337125073>.
- 5) Ackerman MJ, Priori SG, Willems S, et al. HRS/EHRA expert consensus statement on the state of genetic testing for the channelopathies and cardiomyopathies this document was developed as a partnership between the Heart Rhythm Society (HRS) and the European Heart Rhythm Association (EHRA). *Heart Rhythm*. 2011 Aug; 8(8):1308-39. PMID: 21787999. <https://doi.org/10.1016/j.hrthm.2011.05.020>.
- 6) Tan HL, Hofman N, van Langen IM, et al. Sudden unexplained death: heritability and diagnostic yield of cardiological and genetic examination in surviving relatives. *Circulation*. 2005 Jul 12; 112(2):207-13. PMID: 15998675. <https://doi.org/10.1161/CIRCULATIONAHA.104.522581>.
- 7) Tester DJ, Ackerman MJ. The molecular autopsy: should the evaluation continue after the funeral? *Pediatr Cardiol*. 2012 Mar; 33(3):461-70. PMID: 22307399. PMCID: PMC3332537. <https://doi.org/10.1007/s00246-012-0160-8>.

- 8) Semsarian C, Ingles J. Molecular autopsy in victims of inherited arrhythmias. *J Arrhythm*. 2016 Oct; 32(5):359-65. PMID: 27761159. PMCID: PMC5063264. <https://doi.org/10.1016/j.joa.2015.09.010>.
- 9) Post-mortem in sudden unexpected death in the young: guidelines on autopsy practice. [Internet]. [place unknown]: Trans-Tasman Response AGAinst sudden Death in the Young (TRAGADY); [cited 2016 Feb 8]. 29 p. Available from: <https://www.rcpa.edu.au/getattachment/89884c69-f066-411d-a3d1-39460444db13/Guidelines-on-Autopsy-Practice.aspx>.
- 10) Guidelines for the investigation of sudden cardiac death: coroner's investigation and medicolegal autopsy [Internet]. Toronto: Office of the Chief Coroner for Ontario; 2008 Mar 28 [cited 2016 Feb 12]. Available from: <http://www.nsgc.org/d/do/978>.
- 11) Middleton O, Baxter S, Demo E, et al. National Association of Medical Examiners position paper: retaining postmortem samples for genetic testing. *Acad Forensic Pathol*. 2013 Jun; 3(2):191-4. <https://doi.org/10.23907/2013.024>.
- 12) Ackerman MJ. State of postmortem genetic testing known as the cardiac channel molecular autopsy in the forensic evaluation of unexplained sudden cardiac death in the young. *Pacing Clin Electrophysiol*. 2009 Jul; 32 Suppl 2:S86-9. PMID: 19602172. PMCID: PMC3332543. <https://doi.org/10.1111/j.1540-8159.2009.02393.x>.
- 13) MacLeod H, Leighton J, Lynch K, et al. Heart rhythm scientific sessions: review of postmortem clinical genetic testing sample success rates and payors from commercial labs [Internet]. Chicago: National Society of Genetic Counselors; 2014 May [cited 2016 Feb 12]. Available from: <http://www.nsgc.org/d/do/4063>.
- 14) Kane DA, Triedman J. Post-mortem genetic testing in a family with long-QT syndrome and hypertrophic cardiomyopathy. *Cardiovasc Pathol*. 2014 Mar-Apr; 23(2):107-9. PMID: 24322056. <https://doi.org/10.1016/j.carpath.2013.11.003>.
- 15) Arscott P, Caleshu C, Kotzer K, et al. A case for inclusion of genetic counselors in cardiac care. *Cardiol Rev*. 2016 Mar-Apr; 24(2): 49-55. PMID: 26186385. PMCID: PMC4715801. <https://doi.org/10.1097/CRD.0000000000000081>.
- 16) Hershberger RE, Lindenfeld J, Mestroni L, et al. Genetic evaluation of cardiomyopathy-a Heart Failure Society of America practice guideline. *J Card Fail*. 2009 Mar; 15(2):83-97. PMID: 19254666. <https://doi.org/10.1016/j.cardfail.2009.01.006>.
- 17) Sampson BA, Tang Y. Holistic approach to determine cause of autopsy-negative sudden natural death. *J Am Coll Cardiol*. 2017 May 2;69(17):2146-8. PMID: 28449775. <https://doi.org/10.1016/j.jacc.2017.01.068>.
- 18) National Society of Genetic Counselors [Internet]. Chicago: National Society of Genetic Counselors; c2018. Postmortem genetic testing FAQs; [cited 12 December 2016]. Available from: <http://www.nsgc.org/postmortem>.
- 19) Carturan E, Tester DJ, Brost BC, et al. Postmortem genetic testing for conventional autopsy-negative sudden unexplained death: an evaluation of different DNA extraction protocols and the feasibility of mutational analysis from archival paraffin-embedded heart tissue. *Am J Clin Pathol*. 2008 Mar; 129(3):391-7. PMID: 18285261. PMCID: PMC3332542. <https://doi.org/10.1309/VLA7TT9EQ05FFVN4>.
- 20) Müllertz K, Christiansen MK, Broendberg AK, et al. Outcome of clinical management in relatives of sudden cardiac death victims. *Int J Cardiol*. 2018 Jul 1; 262:45-50. PMID: 29598884. <https://doi.org/10.1016/j.ijcard.2018.03.022>.
- 21) Ingles J, Yeates L, Semsarian C. The emerging role of the cardiac genetic counselor. *Heart Rhythm*. 2011 Dec;8(12):1958-62. PMID: 21767518. <https://doi.org/10.1016/j.hrthm.2011.07.017>.