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Development of a list of essential electrocardiogram knowledge for anaesthesiologists

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg in partial fulfilment of the requirements for the degree of Master of Medicine in the branch of Anaesthesiology.

Johannesburg, 2020

Declaration

I, Mariam Moosa, declare that this research report is my own unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Anaesthesiology at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

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01 June 2020

Abstract

Background

It is vital for anaesthetists to be able to record and interpret the electrocardiogram (ECG) correctly. It is important to establish and adhere to professionally developed and validated evidence-based guidelines for ECG interpretation. Content validation is a process that aims to address whether the items on a developed list are content valid or not.

The aim of this study was to develop a list of the essential ECG knowledge for anaesthesiologists.

Methods and results

A prospective, exploratory and instrumental study design using Lynn's two-stage model of determination and quantification of content validity was followed in this study. The Development Stage initially involved a review of the literature by the researcher and was then followed by a peer group discussion with local anaesthesiologists who were Part II examiners for the Fellowship of the College of Anaesthetists of South Africa (FCA(SA)). Every item was debated until consensus was reached. This stage resulted in a list with 93 items. This list was then sent to a national panel of anaesthesiologists, who were also Part II examiners for the FCA(SA), for validation in the Judgement-Quantification Stage. A four-point Likert scale ranging from unnecessary to essential information was used to grade each item. Only items deemed important or essential by the panel were retained. This resulted in 87 of the 93 items being considered content valid. This entire list was quantified using the content validity index (CVI). Lynn suggests that for a list to be considered content valid, it should have a CVI of 0.8. The CVI of this list is 0.9. Therefore, this list is content valid.

Conclusion

A list of essential ECG knowledge for anaesthesiologists has been developed by using a thorough scientific process to ensure content validity.

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Lastly and most importantly, Praise be to God, Lord of the Worlds. The Gracious, The Merciful.

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Abbreviations

ECG	Electrocardiogram
FCA(SA)	Fellowship of the College of Anaesthetists of South Africa
CVI	Content validity index
MINS	Myocardial injury following noncardiac surgery
PMI	Perioperative myocardial infarction
CV	Content validity
CVD	Cardiovascular disease
AV	Atrial ventricular
MI	Myocardial infarction
HPCSA	Health Professionals Council of South Africa

Statement

The Research Report consists of a literature review, draft article, study proposal and appendices. The study proposal is included for background reference and is not for examination.

The formatting of this Research Report complies with the University of the Witwatersrand's Style Guide for Theses, Dissertations and Research Reports. The formatting of the draft article may differ from the rest of the Research Report in order to comply with the author guidelines of the South African Journal of Anaesthesia and Analgesia, the journal to which it is intended to be submitted.

Section 1: Review of the literature

1.1 Introduction

Electrocardiography is defined as “the graphical display of electrical potential differences of an electrical field originating in the heart as recorded at the body surface” (14). The electrocardiogram (ECG) is an invaluable tool in the diagnosis, exclusion, and management of multiple cardiac pathologies. The 3-lead ECG is a standard requirement in emergency departments, intensive care units and operating theatres (22). Medical doctors need to be able to accurately interpret, diagnose and manage the abnormalities found on the ECG to avoid further harm to their patients.

In this section the literature pertaining to the ECG is reviewed. This includes the history and overview of the ECG, the role of the ECG in the perioperative management of a patient and the importance of the ECG skills of an anaesthetist, the ability of computer software systems in ECG interpretation, the knowledge of healthcare workers regarding the ECG, anaesthesiology curricula requirements of ECG skills international and national, core of relevant ECG knowledge including content validity and Lynn’s model for content validity.

1.2 History and overview of the ECG

In 1902 Willem Einthoven developed the string galvanometer and implemented the first clinical ECG (23). He named the waveforms with the letters P, Q, R, S and T; and described many pathological findings on the ECG (24). He received the Nobel Prize for Physiology and Medicine in 1924 for this contribution (24). The string galvanometer which Einthoven used was bulky, large and weighed about 600 pounds (25). It was stationed in Einthoven’s office and connected to the nearby academic hospital by telephone wires via which the recordings were transmitted (25).

At this point the ECG was a standard 3-lead ECG until Wilson and his associates developed the precordial leads (26) and by 1942 Emmanuel Goldberger had developed technology for augmented limb leads and thus was able to form the 12-lead ECG which is still in use today (25).

The standard 12-lead ECG records the potential differences between specific sites on the body surface that alters during the cardiac cycle. It shows alterations in transmembrane voltages in myocardial cells that happen during depolarisation and repolarisation within each cycle (17). A standard 12-lead ECG consists of three limb leads (leads I, II, and III), three augmented limb leads (leads aVR, aVL, and aVF) and six precordial leads (V1 through V6) (17).

With the invention of computer software and their application to the ECG the practitioner can easily gain high quality ECG recordings on printed paper and digitally (26). Most modern ECG machines have software that is able to give a preliminary interpretation of abnormalities (26). However, a clinician is required to review the interpretation due to inaccuracies of the software (27).

Continuous ECG monitoring is standard practice in intensive care units and operating theatres (22) and 12-lead ECGs are a common side-room and preoperative investigation.

1.3 The role of the ECG in the perioperative management of a patient and the importance of the ECG skills of an anaesthetist

The ECG is a frequently used cardiovascular investigation. It is a necessary part of clinical practice and is essential for diagnosing and swiftly commencing treatment in patients with acute coronary syndromes and the most accurate way to diagnose intraventricular conduction disturbances and dysrhythmias. ECG interpretation also assists in the detection of electrolyte abnormalities, such as calcium and potassium levels; and of structural cardiac abnormalities (17). The correction of electrolyte imbalances is vital to prevent haemodynamic instability, dysrhythmias, cardiac arrest and death. The correct identification and recognition of even minor ECG abnormalities, such as conduction delays and fascicular blocks, can have important long-term prognostic implications (28).

As mentioned previously, the 12-lead ECG is a commonly requested investigation in the preparation of patients undergoing surgery. It provides valuable information about the heart rate, rhythm, electrolyte abnormalities and the electrical abnormalities of underlying cardiovascular diseases (29).

Continuous 3- or 5-lead ECG monitoring before induction of anaesthesia and during anaesthesia is currently an accepted standard (22). High risk patients are also monitored with the 3-lead ECG postoperatively (22). Therefore, each anaesthetist is responsible for attaining and maintaining the necessary knowledge and skill in monitoring and interpreting the ECG.

A study in India by George et al (30) showed that the incidence of asymptomatic myocardial injury following non-cardiac surgery (MINS) in patients older than 65 years or older than 45 years with risk factors was 17.5%. The 30-day mortality of patients diagnosed with MINS was 11.7% (30).

Kisten and Biccard (31) investigated the incidence and prognosis of perioperative myocardial infarction (PMI) and MINS in vascular surgical patients admitted to the intensive care unit. They also identified the predictors of PMI and hospital mortality. They looked retrospectively at the electronic hospital records of all the patients aged 45 years and older who were admitted to the hospital's intensive care unit following vascular surgery between the time period of January 2011 and December 2013. There were 140 vascular patients included in this study and it was shown that 24.3% of the patients had a PMI and another 25% had MINS. A hospital mortality of 58.8% for PMI and 20% for MINS was obtained. They also found that PMI and a history of congestive cardiac failure were independent predictors of hospital mortality. This study showed that PMI and MINS were present in almost 50% of vascular surgical patients who were admitted to the intensive care unit postoperatively (31).

Cardiac dysrhythmias are common and one of the most perturbing complications during the perioperative period (4). Several pharmacological agents, non-pharmacological stimuli during anaesthesia and underlying pathophysiology could result in cardiac dysrhythmias (5). Cardiac dysrhythmias may also be accompanied by severe haemodynamic instability and may lead to long term complications (5, 6). It is important for an anaesthesiologist to recognise the dysrhythmias and understand the pathophysiology and management of common cardiac dysrhythmias.

1.4 The ability of computer software systems in ECG interpretation

In 2005, Poon et al (32) investigated the diagnostic performance of a computer-based ECG rhythm algorithm. They studied the computer-based ECG interpretation of a General Electric Healthcare Technologies ECG in 4297 consecutive recordings at a university hospital. Interpretation of the ECGs was also performed by two experienced cardiologists. Sensitivity, specificity, positive predictive values and negative predictive values were then obtained. The results showed that 13.2% of computer-based rhythm statements required revision. Most of the errors were on patients with paced rhythms. The results were then modified to exclude paced rhythms and the result then showed that 7.8% of computer-based rhythm statements required revision. The false-negative rate for sinus rhythm was only 1.3% (sensitivity of 98.7%), but a computer diagnosis of sinus rhythm was incorrect in 9.9% of rhythms (specificity of 90.1%). The false-negative rate for atrial fibrillation was 9.2% (sensitivity of 90.8%), whereas a computer diagnosis of atrial fibrillation was incorrect in 1.1% (specificity of 98.9%) of other rhythms, including sinus rhythm. This study shows that computer diagnosis of paced rhythms remains problematic, and physician interpretation to validate computer-based ECG rhythm diagnoses remains mandatory (32).

In 2012, Hakacova et al (27) compared the ability of two computer ECG interpretation programs with three non-expert clinicians in interpreting 500 ECGs. These were tested against a gold standard of two senior experts. The results showed that the computer programs did not achieve more correct interpretations than the non-expert clinicians and that there were both false-negative and false-positive identifications of a variety of rhythm disturbances, including atrial fibrillation, paced rhythm, ventricular extrasystoles, and ectopic atrial rhythm. Hence clinicians need to be cautious of relying on computer based interpretations (27).

In 2019, Lindow et al (33) described the incidence of erroneous computer interpretation of atrial flutter and atrial fibrillation in a Swedish population, the rate of correction of computer misinterpretation and the consequences of misdiagnosis. The results showed that ECGs with a computer diagnosis of atrial flutter or atrial

fibrillation was incorrect in approximately 10%. It also shows that in approximately half of these incorrect cases, the misdiagnosis was not corrected by the reviewing primary-care physician and thus 12 patients received inappropriate anticoagulant treatment because of this misdiagnosis (33).

A 2019 review by Smulyan (20) concluded that the benefits of ECG computer interpretation are reduction of the physician reading time and the correct interpretation of normal tracings. However, the computer interpretations of the abnormal ECG are often erroneous and must be reviewed by physicians. The diagnosis of myocardial infarction, pacemaker rhythms, atrial fibrillation and lead reversals are the most common and important computer errors. Computer interpretation in addition to reviewing by physicians are the best combination for precise ECG diagnoses (20).

The Recommendations for the Standardization and Interpretation of the ECG, a 2007 scientific statement published by the American College of Cardiology and the American Heart Association (17), states that “computer interpretation of ECG is an adjunct to the electrocardiographer and all computer based reports require physician reviewing” (17). Computer software is improving with time and future studies may show better accuracy with ECG interpretation.

1.5 The knowledge of healthcare workers regarding the ECG

The correct recording and detailed interpretation of the ECG are vital. It is important to establish and adhere to professionally developed and validated evidence-based guidelines for ECG interpretation. This is imperative for ensuring the high level of accuracy in patient management required and expected by clinicians and their patients (17).

Salerno et al (19) noted, in a 2003 review, poor or below expected ECG interpretation skills of medical students; nurses; paramedics; internal medicine, family medicine and emergency medicine residents and physicians; and cardiologists. The authors state that there is a need for standardisation in knowledge acquisition and assessment methodology (19).

Sibbald et al (34) investigated the ECG interpretation skills in 29 cardiology residents of a training program in Canada. Two cardiologists, who each had approximately 25 years of practice experience, selected two packages of 10 similar ECGs with unambiguous diagnoses from a set of successive ECGs collected over one month from a community cardiologists' everyday practice. The residents were then randomised to interpret one of the packages by their own methods and the other by using a familiar analytic framework which focused on key variables in ECG interpretation like rate, rhythm, QRS axis, chamber hypertrophy, abnormal intervals and ischemic changes. Residents were allocated scores by the number of incorrect and correct diagnoses obtained. The overall diagnostic accuracy was 58%. Out of six potentially life-threatening diagnoses, residents scored 36% incorrect, some of which were prolonged QT, complete heart block, hyperkalaemia and ventricular tachycardia. The diagnostic accuracy was similar between the ECGs interpreted using the analytic framework versus those ECGs interpreted without the analytic framework. This study showed that there were significant deficiencies in cardiology resident ECG interpretation even with the use of an analytic framework (34).

Werner et al (35) conducted an investigation in Sweden on ambulance nurses' practical ECG interpretation skills and the correlation between these skills and factors that may have had an impact on these skills. A prospective quantitative survey with a questionnaire was done. Convenience sampling was used. The knowledge test consisted of nine different ECGs. ECG tests scores were then compared and correlated against the questions in the questionnaire regarding general ECG interpretation skill and ability to identify acute myocardial infarction. The results showed that on average respondents were able to identify 54% of the ECGs correctly. They were able to identify 46% of the ECGs showing acute myocardial infarction. There was no correlation between the ECG interpretation skills and factors such as education and professional experience was found, except that those who had previous coronary care unit experience had better scores on the ECG interpretation test (35).

In 2009, De Jager et al (36) investigated the ECG interpretation skills of South African emergency medicine registrars. A prospective cross-sectional study of

emergency medicine registrars and recently qualified emergency medicine physicians was performed using a focused questionnaire. The findings showed that there was an improvement in the interpretation of ECGs with increasing seniority. The overall average score for ECG interpretation was 46.4%. The junior group had an overall average of 42.2%, whereas the senior group got 52.5%. It was concluded that the general performance was poor in both groups and compared adversely to similar international studies. Registrars in Year 4 – 5 showed the largest improvement in ECG skill level, where they were either busy preparing for, or had already passed, the final exam (36).

Hartman et al (37) developed a novel tool for assessment of emergency medicine resident skills in determining diagnosis and management of emergency ECGs. The validity of the tool was then tested on post-graduate students at various levels of training from Year 1 − 4 at five emergency medicine residency programs in the United States. Year 3 and 4 residents averaged 74.6% correct and performed significantly better than Year 1 residents, who averaged 63.2% correct and Year 2 residents who averaged 69.0%. The assessment tool demonstrated improved scores according to years in training, however, it showed that Year 3 and 4 post-graduate students produced lower than expected passing scores (37).

Marshall and Myles (38) investigated the knowledge of the QT interval and the drugs which prolong it among trainee and consultant anaesthesiologists at an adult university-affiliated teaching hospital. This study showed that anaesthesiologists have inadequate knowledge of the QT interval. Only 65% of the participants were able to identify the QT interval correctly and only 2% could identify all the drugs which prolong the QT interval (38).

1.6 Anaesthesiology curricula requirements of ECG skills

International

The various curricula of different anaesthesiology examination boards differ regarding the knowledge level required of anaesthetists in interpreting ECGs. The European Union of Medical Specialities (39), the Australian and New Zealand

College of Anaesthetists (40) and the American Board of Anaesthesiology (41) do not give details about the knowledge required of ECG interpretation.

The Royal College of Anaesthetists (7, 8) and the Royal College of Physicians and Surgeons of Canada (9) curricula have the most detail regarding the ECG knowledge required of anaesthesiologists. However, there are no clear guidelines as to the specific minimum diagnoses required.

The Royal College of Anaesthetists (7, 8) requires candidates to be able to interpret, record, monitor, know the placement of leads, describe the basic principles of ECGs, identify arrhythmias, ventricular tachycardia, ventricular fibrillation, asystole and rhythms associated with pulseless electrical activity, the effects of temperature, ischaemia, infarction and electrolyte abnormalities (7, 8).

The Royal College of Physicians and Surgeons of Canada (9) specifies that the candidates must be able to identify arrhythmias, ischaemia and infarction on a 12-lead ECG and must be able to identify and know the limitations of the ECG and its monitoring intraoperatively. It also states that the candidates should know the specificity and sensitivity of diagnosing myocardial infarction based on ECG interpretation. The candidate should know the placement of leads for 3- and 5-lead ECGs and the limitations when compared to 12-lead ECGs. For preoperative ECG interpretation the candidate must be able to assess the risk and modify perioperative management (9).

National

The College of Anaesthetists of South Africa (10) requires candidates to know how to interpret, record and monitor ECGs. There is no detail about the specific ECG pathology or abnormalities that candidates are required to know. It also lacks guidelines for the training of registrars in this regard.

The evaluation of ECG skills is done as part of the general examination process; ECG questions form part of the written and practical evaluation of the Fellowship of the College of Anaesthetists Part II examination. There are no specific data regarding the training and proficiency in ECG interpretation.

1.7 Core of relevant ECG knowledge

There are limited studies and competence statements regarding knowledge of the ECG specific to the discipline of anaesthesiology. However there is a competence statements in the literature for cardiologists (14) and a study that provides a list of adult ECG diagnoses for emergency medicine physicians (15).

The American College of Cardiology and the American Heart Association (14) has published a clinical competence statement on ECG and ambulatory ECG. This statement defines the ECG knowledge required of cardiologists. The statement thus assists those who must judge the competency of professionals entering the cardiology discipline and those who must undergo review of their competence. The statement was based on evidence and when evidence was not available then expert opinion was sought in obtaining the recommendations listed (14).

Patocka et al (15) in Canada investigated “What adult ECG diagnoses and or findings do residents in emergency medicine need to know”. A Delphi technique using purposive sampling of emergency medicine physicians was done. The panellists for the online consensus building process were emergency medicine training program directors in Canada, from the Royal College of Physicians and Surgeons of Canada training programs and the College of Family Physicians fellowship programs, and an emergency medicine physician with expertise in emergency electrocardiography. Consensus was defined as at least 75% agreement on the rating of any one item at Round 2 or later. In the absence of consensus, stability of opinion was determined. Stability was determined as “the consistency of answers between successive rounds of the study and it was defined as a shift of 20% or less after successive rounds”. There is significant disagreement in the literature regarding consensus and stability, so these values were determined beforehand and were based on values used in similar studies. When an item achieved consensus or stability, it was removed from further rounds of the Delphi process. Out of the 121 items on the proposed list of diagnoses, the process produced a list of 78 diagnoses that reached consensus, 42 which achieved stability and one which reached neither consensus nor stability (15).

D'Eon and Crawford (21) have explored a variety of methods for determining content of undergraduate medical school curriculum. These methods can also be applied to postgraduate curriculum content. A key problem for curriculum and course planners is dealing with the increasing knowledge base and therefore there is a tendency to include large amounts of information in the curriculum. It is better to rather identify a manageable core of relevant knowledge. A way of doing this is to obtain expert opinion regarding the relevance of information. There is a need for better and more thorough efforts to provide useful information to curriculum planners. There needs to be a focus on obtaining the specific content that will result in the best educational outcomes for the learners (21).

A core of relevant ECG knowledge for anaesthesiologists can be developed by doing a content validity study.

Content Validity

Validity is the determination by one or more content experts that the items of an instrument or construct represent the content domain being assessed. It is the extent to which the instrument measures what it is intended to measure (11).

Content validity (CV) is defined as the degree to which a sample of items constitutes an adequate operational definition of a given construct. The process of CV involves two phases: priori efforts by the investigator to enhance CV through conceptualisation and domain analysis to develop and generate the items; and posteriori efforts to determine relevance based on expert assessment (12).

The premise behind CV is that content experts agree that items are relevant to the construct which is being examined. The information gained from CV assists educators and researchers to revise, delete or substitute items in the construct or list. A content validity index (CVI) is calculated for the individual items. The CVI of the entire list or construct is also determined when the research results are analysed and reported (42).

Rutherford-Hemming (42) suggested elements that assist researchers in ensuring thoroughness of the content validation process. Open-ended questions should be included by the researcher at the end of the CV form to give the experts an

opportunity to add content or items that may be missing from the list. The researcher must ensure that the content experts are actual experts who have published or presented. They should be well known for their expertise in the content area being validated. If CV is only obtained from local experts in the researchers' own workplace or academic community who do not have an expert presence outside their own workplace, then this may limit CV ratings and comments to reflect only local standards. Researchers should be aware that local experts who know the researcher personally may be hesitant to adequately critique the items. The researcher should send the CV form to experts anonymously where possible and provide a way for the experts to return the questionnaires anonymously to enhance unbiased ratings and comments. The content experts are more likely to be frank about the relevance of the items in the construct if they are blinded to the researcher (42).

Lynn's Model for content validity

In this study Lynn's Model for content validity will be used to develop a list of essential ECG knowledge for anaesthesiologists and will be briefly discussed. Lynn's model (11) was originally described in 1986 and is a widely used method of obtaining CV. Despite its long history it is still recommended by researchers for CV. Polit and Beck (12) described CVI in 2006 and recommend using Lynn's criteria.

Lynn (11) has described the process of CV as having two stages, namely the Developmental Stage and the Judgement/Quantification stage. The Developmental Stage has three steps: domain identification, item generation and instrument formation. Domain identification begins with a thorough review of the literature available on the subject under question. This would incorporate the ideas and opinions of a variety of published experts. Item generation is the next step, which involves creating a list of items that need to be validated further. More items are better than less at this stage (11). Instrument formation is the next process, which is the construction of the items into an assembled instrument. The items generated are refined and arranged into an orderly sequence (11).

The next stage is the Judgement/Quantification Stage and involves the opinion and assertion by specific experts in the field that the individual items and the entire instrument are content valid. A minimum of three experts should be used. If only two experts are used, the results become statistically unjustifiable. The questions addressed to the experts should be clear and defined. They must not be ambivalent and should pose easily answerable questions to the experts (11).

The results are then analysed and a CVI is obtained (13). The experts are asked to rate the relevance of an item on an ordinal or Likert scale which may be 3-, 4- or 5- point. The 4- point scale is preferred as it eliminates the ambivalence of the middle rating (11). The CVI is calculated for each item and then for the instrument as a whole (13). The item level CVI is called I-CVI and the instrument CVI is called S-CVI (13). The I-CVI represents the proportion of agreement on the relevance of each item and the S-CVI is the proportion of total items judged content valid (13).

1.8 Summary

The ability of an anaesthetist to accurately interpret a 3-, 5- and 12-lead ECG is imperative for patient management. There is a paucity of literature regarding ECG skills and ECG skill requirements of the anaesthetist, and therefore there needs to be further investigation and agreement into the required ECG knowledge of anaesthetists. It would be valuable to those preparing for exams and medical officers, consultants and registrars in everyday practice when confronted with complicated diagnoses, which may or may not require the input of cardiologists. A content validity study would be one way of defining the requirements.

In this section the literature pertaining to the electrocardiogram (ECG) was reviewed. This included the history and overview of the ECG, the role of the ECG in the perioperative management of a patient and the importance of the ECG skills of an anaesthetist, the ability of computer software systems in ECG interpretation, the knowledge of healthcare workers regarding the ECG, anaesthesiology curricula requirements of ECG skills including international and national, core of relevant ECG knowledge including content validity and Lynn’s model for content validity.

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The following are sample references:

1. Jun BC, Song SW, Park CS, Lee DH, Cho KJ, Cho JH. The analysis of maxillary sinus aeration according to aging process: volume assessment by 3-

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Section 2: Draft article

Development of a list of essential electrocardiogram knowledge for anaesthesiologists

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Abstract

Background

It is vital for anaesthetists to be able to record and interpret the electrocardiogram (ECG) correctly. It is important to establish and adhere to professionally developed and validated evidence-based guidelines for ECG interpretation. Content validation is a process that aims to address whether the items on a developed list are content valid or not.

The aim of this study was to develop a list of the essential ECG knowledge for anaesthesiologists.

Methods and results

A prospective, exploratory and instrumental study design using Lynn's two-stage model of determination and quantification of content validity was followed in this study. The Development Stage initially involved a review of the literature by the researcher and was then followed by a peer group discussion with local anaesthesiologists who were Part II examiners for the Fellowship of the College of Anaesthetists of South Africa (FCA(SA)). Every item was debated until consensus was reached. This stage resulted in a list with 93 items. This list was then sent to a national panel of anaesthesiologists, who were also Part II examiners for the FCA(SA), for validation in the Judgement-Quantification Stage. A four-point Likert scale ranging from unnecessary to essential information was used to grade each item. Only items deemed important or essential by the panel were retained. This resulted in 87 of the 93 items being considered content valid. This entire list was quantified using the content validity index (CVI). Lynn suggests that for a list to be considered content valid, it should have a CVI of 0.8. The CVI of this list is 0.9. Therefore, this list is content valid.

Conclusion

A list of essential ECG knowledge for anaesthesiologists has been developed by using a thorough scientific process to ensure content validity.

Introduction

The ECG is a non-invasive, inexpensive tool in the diagnosis, exclusion and management of multiple cardiac pathologies. In the discipline of anaesthesiology, the ECG is used during preoperative assessment and intraoperative monitoring of patients (1).

The 12-lead ECG is a frequently requested investigation in the preoperative management of a patient (2). It is important for an anaesthetist to be able to interpret the ECG and adjust the anaesthetic management of the patient accordingly. The anaesthetist should also be able to diagnose and treat acute ECG changes in emergency situations while monitoring the 3- or 5-lead ECG in theatre.

The Global Burden of Diseases, Risk Factors, and Injuries 2010 Study (3) estimated that the cardiovascular disease (CVD) burden has increased in sub-Saharan Africa since 1990, with the largest increases being for atrial fibrillation and peripheral arterial disease. Ischaemic heart disease was the second most common cause of CVD death and disability. CVD deaths amounted to 8.8% of all deaths in sub-Saharan Africa, which was less than the percentage of morbidity and mortality of CVD in more developed areas. It was notable however, that the average age of CVD death in sub-Saharan Africa was 64,9 years which was the youngest in the world according to this study (3). Hence the anaesthetist in South Africa is likely to encounter patients with CVD and must be proficient in the interpretation of the ECG.

Cardiac dysrhythmias are common and one of the most perturbing complications during the perioperative period (4). Several pharmacological agents, non-pharmacological stimuli during anaesthesia and underlying pathophysiology could result in cardiac dysrhythmias (5). Cardiac dysrhythmias may also be accompanied by severe haemodynamic instability and may lead to long term complications (5, 6). It is important for an anaesthetist to be able to recognise the dysrhythmias and understand the pathophysiology and management of common cardiac dysrhythmias.

In keeping up to date and maintaining the skills of ECG interpretation, no clear guidelines of what an anaesthetist should know about ECG were found. The Royal College of Anaesthetists (7, 8) and the Royal College of Physicians and Surgeons of Canada (9), which includes anaesthesiology post graduate training, have more detailed information regarding ECG in their curricula statements than the College of Anaesthetists of South Africa (10).

The question arises as to whether the ECG knowledge and skills of the anaesthetist are adequate for the detection of abnormalities and the treatment or optimisation of these abnormalities. Anaesthesiology post-graduate programs must ensure the competence of their trainees in this important skill. In any training or learning process, it is important that trainees are provided with as much detail of the cognitive requirements as possible.

The aim of this study was to develop a list of the essential ECG knowledge for anaesthesiologists following Lynn's two-stage model (11). This expert validated list can be used by anaesthetists and anaesthesiologists in obtaining and maintaining competence in ECG skills, and in the teaching of registrars and medical officers in anaesthesiology departments.

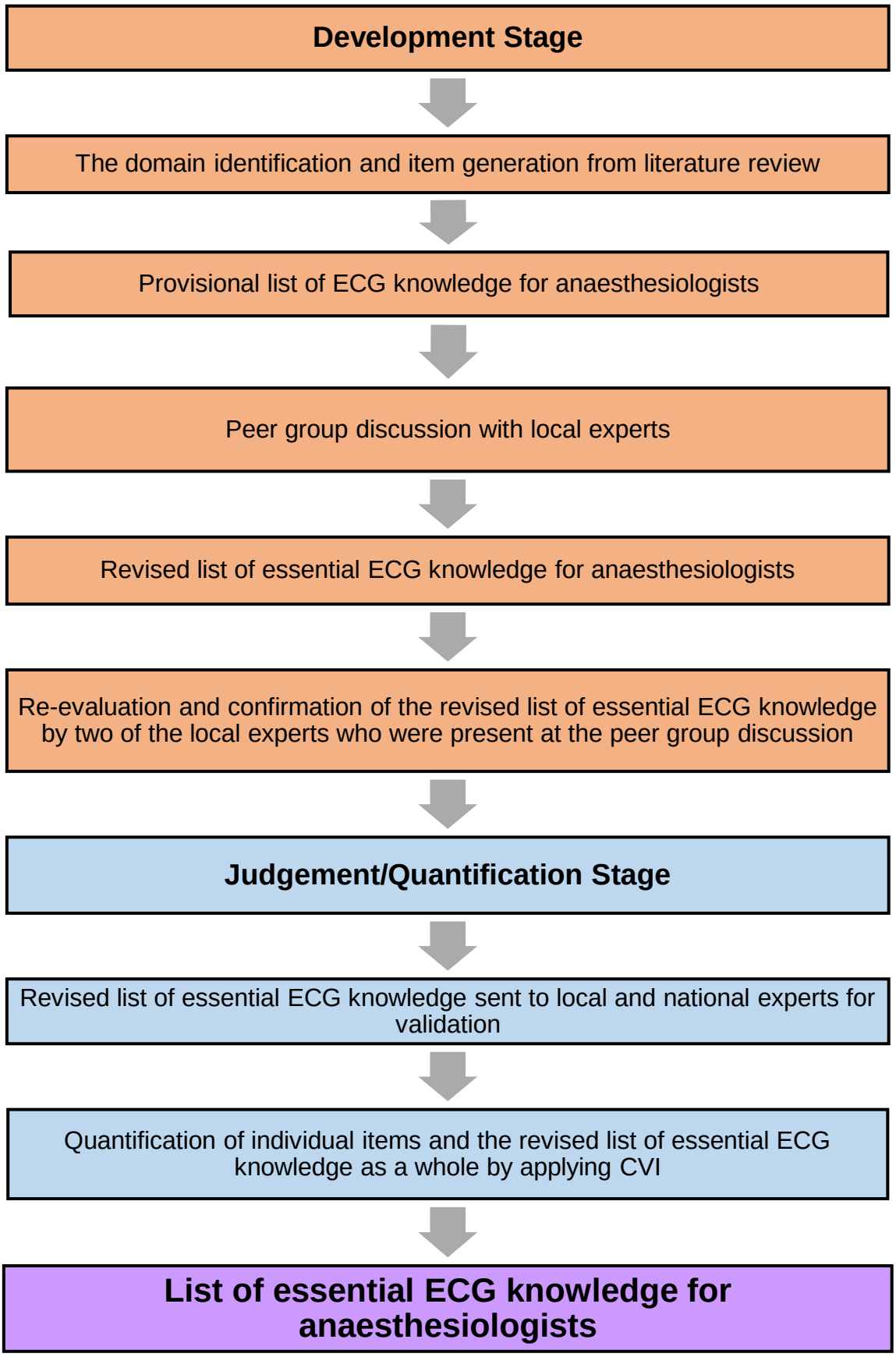
Methods and results

Lynn's model (11) was originally described in 1986 and is a widely used method for obtaining content validity (CV) (12). Lynn (11) has described the process of CV as having two stages, namely the Developmental Stage and the Judgement/Quantification Stage. The Developmental Stage has three steps: domain identification, item generation and item formation. The Judgement/Quantification Stage involves the opinion and assertion by specific experts in the field that the individual items and the entire list are content valid. The results are then analysed and a content validity index (CVI) for each item and for the entire list is obtained (13).

Approval was obtained from the Human Research Ethics Committee (Medical) and other relevant authorities of the University of the Witwatersrand. A prospective, exploratory and instrumental study design was followed. Purposive sampling was used in both stages. The study population consisted of South African

anaesthesiologists who were Fellowship of the College of Anaesthetists of South Africa Part II examiners and who will henceforth be referred to as experts in this study. As the stages follow onto one another the methodology, data analysis and results will be discussed in each stage. The stages and a summary of the methodology are shown in Figure 1.

Figure 1 – Stages and summary of the methodology



Stage 1: Development Stage

Domain identification and item generation, which are the first two steps of the Development Stage, were done by reviewing the literature and were based on the American College of Cardiology and American Heart Association Clinical Competence Statement on Electrocardiography and Ambulatory Electrocardiography (14) and a study by Patocka et al (15). A provisional list of essential ECG knowledge for anaesthesiologists which consisted of 14 domains and 110 items was generated. For the third step (item formation), a peer group discussion was held to consider and enhance the provisional list in order to develop the revised list.

An information letter requesting participation in the study and providing the provisional list of essential ECG knowledge for anaesthesiologists was given to 16 experts from the University of the Witwatersrand. Six of the invited experts attended the peer group discussion facilitated by one author (MM). During the peer group discussion, the participants were asked to review and grade each item on the provisional list according to the following Likert scale:

- 1 = do not need to know
- 2 = nice to know but not necessary
- 3 = should know
- 4 = must know.

The aim of the peer group discussion was to refine, expand and alter the provisional list to ultimately enhance the CV. Each item on the provisional list was debated until 100% consensus was reached. Fifteen items were removed from the list as they scored 1 or 2 on the Likert scale and two were removed as the experts believed they were already covered in other items and including them would be repetitive. Table 1 shows the items that were removed after the peer group discussion.

Table 1 – Items removed from the list in the Development Stage

Item removed	Reason for removal
Sino-atrial exit block	Scored 2
Atrial premature complexes, non-conducted	Scored 2
Accelerated idioventricular rhythm	Scored 2
Juvenile T waves (normal variant)	Scored 2
Failure of appropriate inhibition, atrial	Scored 2
Failure of appropriate inhibition, ventricular	Scored 2
Retrograde atrial activation	Scored 2
End stage renal disease	Scored 1
Endocardial cushion defect	Scored 2
Hypothyroidism	Scored 1
Long QT syndrome	Scored 2
Orthotopic heart transplant	Scored 2
Primary pulmonary hypertension or pulmonary stenosis	Scored 2
Secundum atrial septal defect	Scored 2
Torsades de Pointes	Covered elsewhere
Wolff-Parkinson-White syndrome	Covered elsewhere
RV dysplasia	Scored 2

After finishing the peer group discussion, the necessary changes according to the peer group recommendations were made and the revised list of essential ECG knowledge for anaesthesiologists consisting of 14 domains (A − N) and 93 items (Table 2) was prepared for the Judgement/Quantification Stage.

Table 2 − Revised list of essential ECG knowledge for anaesthesiologists and the rating of the items by the 24 experts and the CVI of each item

	ECG diagnoses	1	2	3	4	CVI
A	**Normal tracing**					
1	Normal ECG				24	1
B	**Technical problems**					
2	Leads Misplaced		1	2	21	0.96
3	Artefacts			3	21	1
C	**Sinus node rhythms and arrythmias**					
4	Sinus rhythm				24	1
5	Sinus tachycardia				24	1
6	Sinus bradycardia				24	1
7	Sinus arrythmia			3	21	1
8	Sinus arrest or pause		1	4	19	0.96
D	**Other supraventricular rhythms**					
9	Atrial premature complexes		2	7	15	0.92
10	Ectopic atrial rhythm		3	8	13	0.88
11	Ectopic atrial tachycardia, unifocal		1	11	12	0.96
12	Ectopic atrial tachycardia, multifocal		2	9	13	0.92
13	Atrial fibrillation				24	1
14	Atrial flutter				24	1
15	Junctional premature complexes		1	11	12	0.96
16	Junctional escape complexes or rhythm			12	12	1

17	Accelerated junctional rhythm		5	9	10	0.79
18	Junctional tachycardia, automatic		4	8	12	0.83
19	Supraventricular tachycardia, paroxysmal		1		23	0.96
E	**Ventricular arrhythmias**					
20	Ventricular premature complexes			2	22	1
21	Ventricular escape complexes or rhythm			6	18	1
22	Ventricular tachycardia				24	1
23	Ventricular tachycardia, polymorphous (including torsades de pointes)				24	1
24	Ventricular fibrillation				24	1
F	**Atrial ventricular conduction**					
25	First degree AV block				24	1
26	Mobitz Type 1 second degree AV block (Wenckebach)			1	23	1
27	Mobitz Type 2 second degree AV block			1	23	1
28	AV block or conduction ratio, 2:1			1	23	1
29	AV block, varying conduction ratio		2	4	18	0.92
30	AV block, advanced (high-grade)			5	19	1
31	AV block, complete (third degree)				24	1
32	AV dissociation			4	20	1
G	**Intraventricular conduction**					
33	Left bundle branch block			1	23	1
34	Right bundle branch block			3	21	1
35	Intraventricular conduction delay, nonspecific		2	9	13	0.92
36	Aberrant conduction of supraventricular beats	1	4	10	9	0.79
37	Left anterior fascicular block		2	7	15	0.92
38	Left posterior fascicular block		2	7	15	0.92
39	Ventricular pre-excitation (Wolff-Parkinson-White pattern)			3	21	1
H	**QRS axis and voltage**					
40	Right axis deviation			2	22	1
41	Left axis deviation			1	23	1
42	Indeterminate axis		2	9	13	0.92
43	Electrical alternans			12	12	1
44	Low voltage (less than 0.5 mV total QRS amplitude in each extremity lead and less than 1.0 mV in each Precordial lead)		5	9	10	0.79
I	**Chamber hypertrophy or enlargement**					
45	Left atrial enlargement, abnormality, or conduction defect			3	21	1
46	Right atrial abnormality			6	18	1
47	Left ventricular hypertrophy (QRS abnormality only)			1	23	1
48	Left ventricular hypertrophy with secondary ST-T abnormality			5	19	1
49	Right ventricular hypertrophy with or without secondary ST-T abnormality			7	17	1
J	**Repolarisation abnormalities**					
50	Early repolarisation (normal variant)		8	11	5	0.67
51	Nonspecific abnormality, ST segment and/or T wave		1	10	13	0.96
52	ST and/or T wave suggests ischaemia				24	1
53	ST suggests injury			4	20	1
54	ST suggests ventricular aneurysm		7	12	5	0.71
55	Q-T interval prolonged			2	22	1
56	Prominent U waves		2	9	13	0.92
K	**Myocardial infarction**					

57	Inferior MI (acute or recent)			1	23	1
58	Inferior MI (old or age indeterminate)			5	19	1
59	Posterior MI (acute or recent)			3	21	1
60	Posterior MI (old or age indeterminate)			9	15	1
61	Septal MI (acute or recent)			4	20	1
62	Anterior MI (acute or recent)				24	1
63	Anterior MI (old or age indeterminate)			5	19	1
64	Lateral MI (acute or recent)			1	23	1
65	Lateral MI (old or age indeterminate)			6	18	1
66	Right ventricular infarction (acute)			4	20	1
L	**Clinical disorders and electrolyte deficiencies**					
67	Chronic pulmonary disease pattern	1		9	14	0.96
68	Acute pericarditis			8	16	1
69	Suggests hypokalaemia			6	18	1
70	Suggests hyperkalaemia			2	22	1
71	Suggests hypocalcaemia		2	12	10	0.92
72	Suggests hypercalcemia		2	12	10	0.92
73	Suggests CNS disease	1	6	15	2	0.71
M	**Pacemaker**					
74	Atrial-paced rhythm		1	8	15	0.96
75	Ventricular-paced rhythm			6	18	1
76	Atrial-sensed ventricular-paced rhythm			14	10	1
77	AV dual-paced rhythm			13	11	1
78	Failure of appropriate capture, atrial		4	7	13	0.83
79	Failure of appropriate capture, ventricular		3	6	15	0.88
80	Failure of appropriate pacemaker firing		2	12	10	0.92
81	Pacemaker mediated tachycardia		9	5	10	0.63
N	**Other clinical disorders**					
82	Dextrocardia		5	12	7	0.79
83	Digitalis toxicity		3	11	10	0.88
84	Hypertrophic cardiomyopathy		4	7	13	0.83
85	Hypothermia		1	11	12	0.96
86	Mitral stenosis		1	4	19	0.96
87	Parkinsonian tremor		14	7	3	0.42
88	Pericardial effusion		4	9	11	0.83
89	Pulmonary embolism			2	22	1
90	Sick sinus syndrome		1	13	10	0.96
91	Tricyclic antidepressant overdose		10	9	5	0.58
92	Brugada Syndrome		8	12	3	0.63
93	Wellens' Syndrome	3	9	6	6	0.50

The revised list was e-mailed to two of the experts who attended the peer group discussion to confirm the changes. These two experts confirmed that the appropriate changes had been made. This stage did not require data analysis as each item was discussed until consensus was reached. The experts based their decisions on the significance of each item in clinical practice.

Stage 2: Judgement/Quantification Stage

The Judgement/Quantification Stage of Lynn's Model has two steps. The first is the assertion by a specific number of experts that the items of the list are content valid. The second step is the assertion that the entire list is content valid (11).

Lynn (11) states that the quantification of content validity can be achieved with the CVI. The CVI is derived from the rating of the items using an ordinal rating scale. The CVI is calculated for each item and then for the list as a whole (13). The CVI for each item represents the proportion of agreement with each item and the CVI for the entire list is the proportion of the items judged as content valid (13).

National experts were selected for this stage. Those experts who had participated in the Development Stage were excluded. The heads of departments of anaesthesiology of eight South African medical schools were contacted by email and or telephone and asked to invite the experts in their respective departments to participate. Those who agreed to participate were then emailed an information letter and a link to an anonymous Google Form which contained the revised list and instructions to rate it on the same Likert scale used in the Development Stage. A total of 24 experts responded to the link and completed the Google Form. The data from the Google Form was then entered into a Microsoft Excel® spread sheet.

The data were analysed by calculating the CVI for each item and then for the entire list. Table 2 shows the revised list of essential ECG knowledge for anaesthesiologists and the rating of the items by the 24 experts and the content validity index (CVI) of each item.

For an item on the list to be content valid, 17 out of 24 of the national experts were required to rate the item as either 3 or 4 on the Likert scale (16). Figure 2 and 3 show the content validity of each item and those that attained content validity are at or above the solid line of 17.

Figure 2 – Rating of the items in the domains A to G

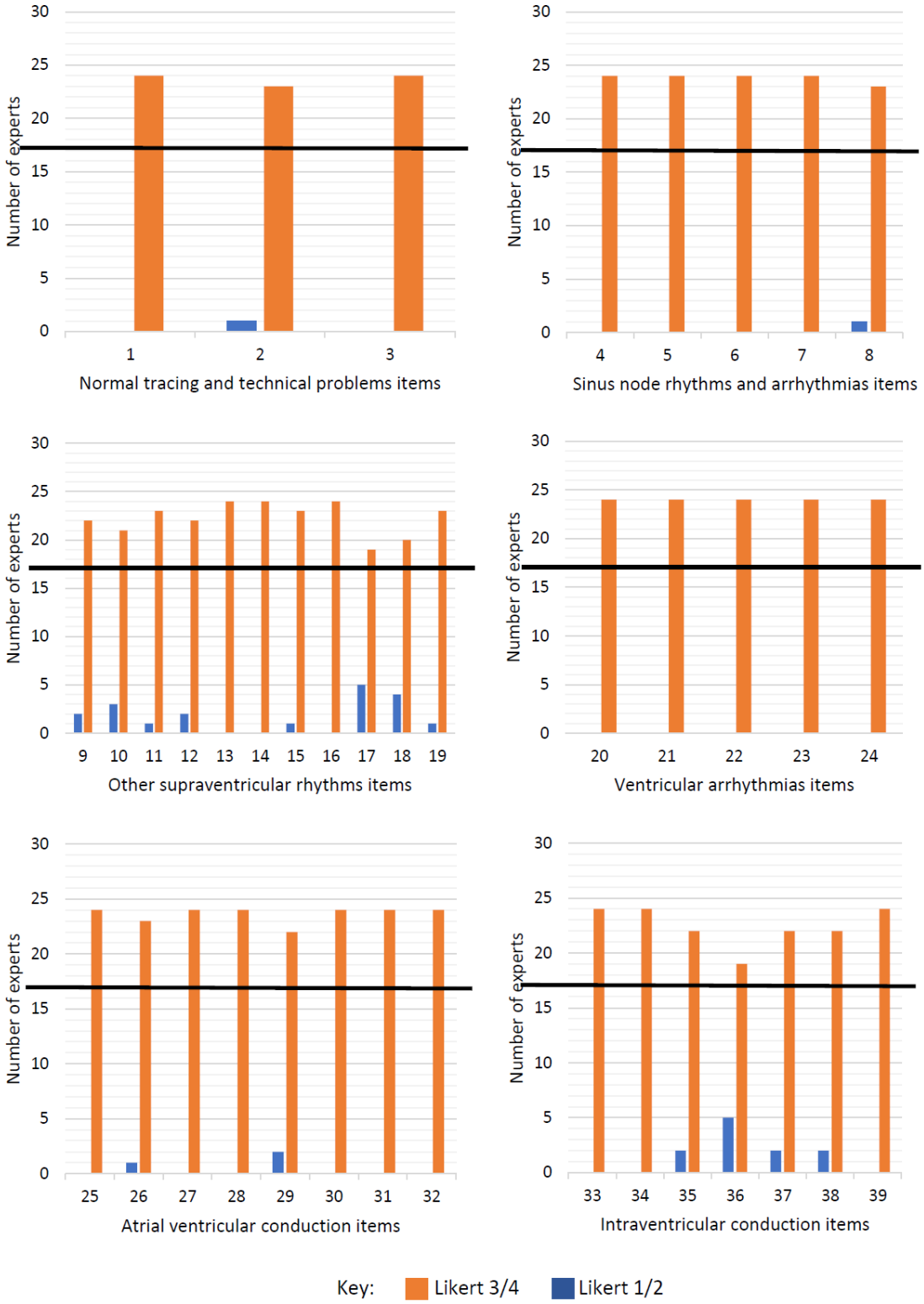


Figure 2: Rating of the items in the domains A to G

Figure 3 – Rating of the items in the domains H to N

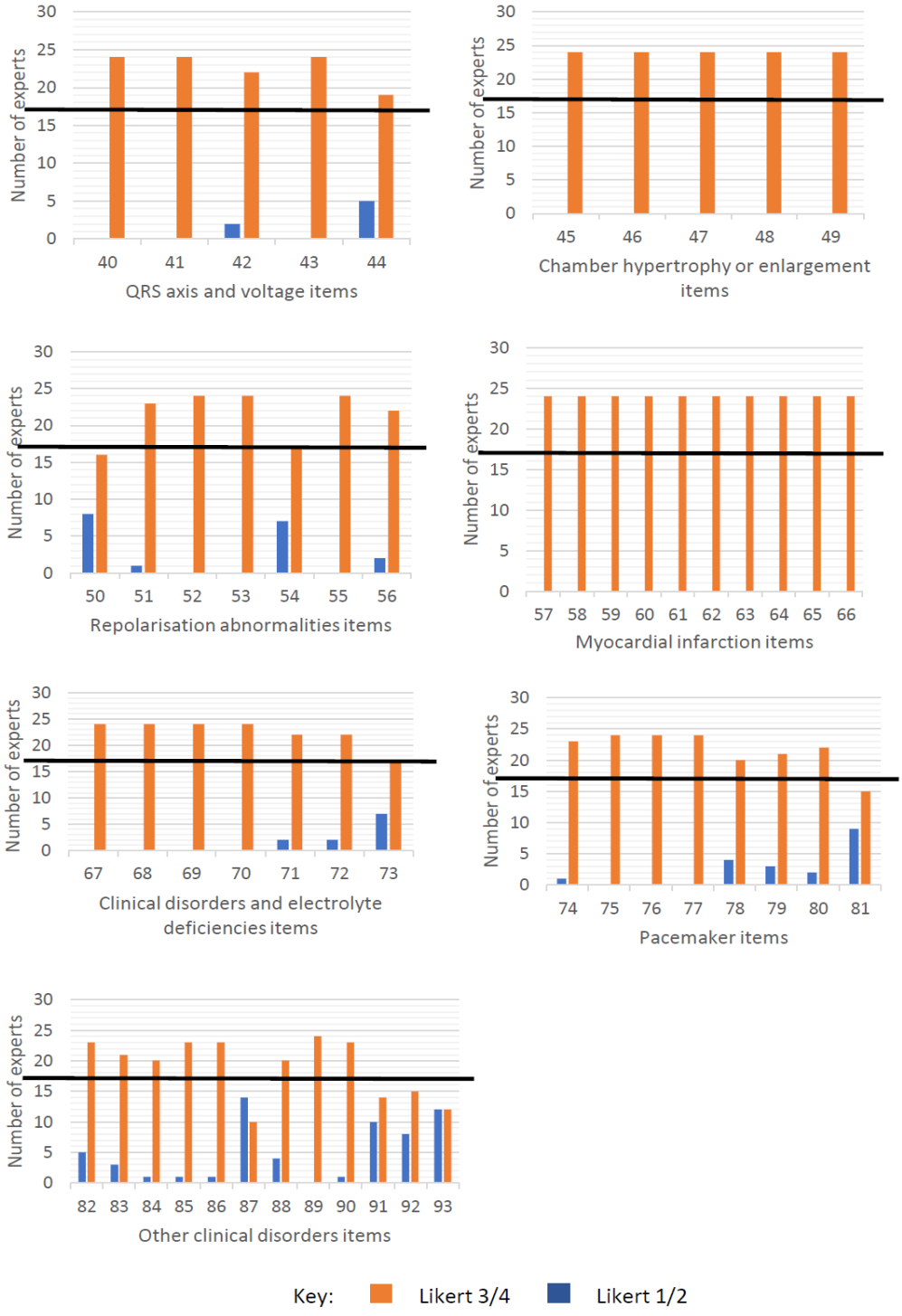


Figure 3: Rating of the items in the domains H to N

Six items were removed from the list in the Judgement/Quantification Stage as there were less than 17 experts that rated these items as 3 or 4. These items are shown in Table 3.

Table 3: Items removed in the Judgement/Quantification Stage

Number	Item
50	Early repolarisation (normal variant)
81	Pacemaker mediated tachycardia
87	Parkinsonian tremor
91	Tricyclic antidepressant overdose
92	Brugada Syndrome
93	Wellens' Syndrome

Finally, CVI was used to quantify the content validity of the entire list. It is recommended that a new content valid list should have a CVI of at least 0.8 (12). This index is the percentage of items deemed as relevant by obtaining a rating of 3 or 4. In this study, 87 out of 93 (94%) items were deemed as relevant by the experts, thereby giving the list a CVI of 0.9.

Discussion

The correct recording and detailed interpretation of the ECG are vital. It is important to establish and adhere to professionally developed and validated evidence-based guidelines for ECG interpretation. This is imperative for ensuring the high level of accuracy in patient management required and expected by clinicians and their patients (17).

In a 2018 review by Breen et al (18), it was noted that up to 33% of ECG interpretations contain major errors. Physician and other disciplines' interpretations of ECG tracings do not always show a high level of intra and interrater reliability. Cardiologists recognise between 53% and 96% of the abnormalities on an ECG correctly. Non-cardiologists interpret, between 36% and 96% of abnormalities correctly (18).

Salerno et al (19) noted, in a 2003 review, poor or below expected ECG interpretation skills of medical students; nurses; paramedics; internal medicine,

family medicine and emergency medicine residents and physicians; and cardiologists. The authors state that there is a need for standardisation in knowledge acquisition and assessment methodology (19). However, there are limited studies about ECG interpretation specific to the discipline of anaesthesiology.

Computer interpretation of ECG cannot be relied on due to the high incidence of errors and must be reviewed by a physician. A 2019 review by Smulyan (20) concluded that the benefits of ECG computer interpretation are reduction of the physician reading time and the correct interpretation of normal tracings. However, the computer interpretations of the abnormal ECG are often erroneous and must be reviewed by physicians. The diagnosis of myocardial infarction, pacemaker rhythms, atrial fibrillation and lead reversals are the most common and important computer errors. Computer interpretation in addition to reviewing by physicians are the best combination for precise ECG diagnoses (20).

D'Eon and Crawford (21) have explored a variety of methods for determining content of undergraduate medical school curriculum. These methods can also be applied to postgraduate curriculum content. A key problem for curriculum and course planners is dealing with the increasing knowledge base and therefore there is a tendency to include large amounts of information in the curriculum. To identify a manageable core of relevant knowledge is a better way of dealing with this. One way of doing this is to obtain expert opinion regarding relevance of information. There is a need for better and more thorough efforts to provide useful information to curriculum planners. There needs to be a focus on obtaining the specific content that will result in the best educational outcomes for the learners (21).

In this study we developed a list of essential ECG knowledge for anaesthesiologists to guide the teaching of medical officers and registrars in our department as we noted that the curriculum is not specific. This study does not suggest or imply that the anaesthesiologist’s knowledge of ECG should be limited to a single checklist but rather there should be an integration of knowledge and clinical skills applied specifically to the discipline of anaesthesiology. Other than the ability to recognize the ECG diagnoses listed, anaesthesiologists should also

be able to manage patients with these conditions and apply the interpretation to the clinical context of the individual patient.

Conclusion

There is a lack of adequate guidelines for anaesthesiologists in attaining and maintaining competence in the interpretation of the ECG in the South African context. In this study, an expert validated list of essential ECG diagnoses for anaesthesiologists was developed. This list would be beneficial for the practicing anaesthetist and anaesthesiologist in maintaining clinical competence, the trainee anaesthetist in obtaining competence, and the academic staff in teaching the registrars and medical officers in anaesthesiology departments.

Conflict of interest

The authors declare that we have no financial or personal relationships which may have inappropriately influenced us in writing this paper.

Acknowledgement

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Section 3: Proposal

Development of a list of the essential electrocardiogram knowledge for anaesthesiologists

Mariam Moosa

0601824

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Co-supervisor	Helen Perrie Department of Anaesthesiology
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3.1 Introduction and problem statement

Electrocardiography is a recording of the electrical activity of the heart at the body surface (1). The electrocardiogram (ECG) is a non-invasive, inexpensive tool in the diagnosis, exclusion and management of multiple cardiac pathologies. In the discipline of anaesthesiology, the ECG is used during preoperative assessment and intraoperative monitoring of patients (2).

The 12-lead ECG is a frequently requested investigation in the preoperative management of a patient (3). It is important for an anaesthetist to be able to interpret the ECG and adjust the anaesthetic management of the patient accordingly. The anaesthetist should also be able to diagnose and treat acute ECG changes in emergency situations while monitoring the 3- or 5-lead ECG in theatre.

The incidence of cardiovascular disease and cardiovascular risk in patients undergoing surgical procedures has increased over time. A 2018 study by Smilowitz et al (4) showed that the prevalence of atherosclerotic cardiovascular disease in adult patients 45 years and older undergoing non-cardiac surgery was 24.3% and the prevalence of two or more cardiovascular risk factors was 44.5%. These numbers are markedly increased from an older study published in 1987 showing the prevalence of patients on treatment for cardiovascular disease undergoing non-cardiac surgery as 10% to 16% (5). The 10% was obtained from a retrospective analysis of 57176 patients and 16% was obtained from prospective analysis of 216 patients.

A 2018 study by George et al (6) showed that the incidence of asymptomatic myocardial injury following non-cardiac surgery in patients 45 years and older with risk factors and 65 years and older was 17.5%. Hence the current anaesthetist is more likely to encounter patients with cardiovascular risk factors and disease.

In keeping up to date and maintaining the skills of ECG interpretation, no clear guidelines of what an anaesthesiologist should know about ECG was found.

The Royal College of Anaesthetists (7, 8) and the Royal College of Physicians and Surgeons of Canada (9) have more detailed information regarding ECG in their

curricula statements as compared to the College of Anaesthetists of South Africa (10). The College of Anaesthetists of South Africa's curriculum states "In providing anaesthesia care, Trainees should be competent in certain technical skills, such as the following: ECG recording and interpretation … Technical skills in which Trainees should be competent include the following: Interpretation of ECGs and ECG monitoring" (10).

In view of the above, the question arises as to whether the ECG knowledge and skills of the anaesthetist is adequate for the detection of abnormalities and the treatment or optimisation of these abnormalities.

In any learning process, it is important that learners (registrars) are provided with as much detail of the cognitive requirements as possible.

3.2 Aim and objectives

3.2.1 Aim

The aim of this study is to develop a list of the essential ECG knowledge for anaesthesiologists following Lynn's two-stage model (11).

3.2.2 Objectives

The objectives of this study are to**:**

- develop a provisional list of essential ECG knowledge from the literature using Lynn's Development Stage (domain identification and item generation)
- develop a revised list of essential ECG knowledge using Lynn's Development Stage (item formation)
- determine content validity of the revised list of essential ECG knowledge using Lynn's Judgement/Quantification Stage (11).

3.3 Research assumptions

The following definitions will be used in this study.

Anaesthetist: is any qualified doctor administering anaesthesia including interns, medical officers, registrars, career medical officers and specialists.

Anaesthesiologist: is a medical doctor who has undergone postgraduate training and examination in anaesthesia and is registered as a specialist in anaesthesiology with the HPCSA.

Expert: an anaesthesiologist who is an FCA(SA) Part II examiner with the College of Anaesthetists of South Africa.

Lynn's Model: a model described by Lynn (11) that involves a two stage process in developing an instrument and achieving content validity of the instrument.

3.4 Ethical considerations

Ethical approval will be obtained from the Human Research Ethics Committee (Medical) and the Graduate Studies Committee of the University of the Witwatersrand.

Experts will be invited to participate in this study. An information letter will be mailed to the experts in the Development Stage (Appendix 1) and other experts in the Judgement/Quantification Stage (Appendix 2). The experts who consent to participate will then be mailed more information and the provisional list for that stage.

For the Development Stage, anonymity cannot be ensured due to the discussion to be had as a peer group. In the Judgement/Quantification Stage, a measure of anonymity will be ensured as the online questionnaire asks for no identifying information. The researcher and supervisors will be the only people with access to the raw data thereby ensuring confidentiality. The data to be captured will contain no identifying information of any participant. Participants will be requested to not divulge the information to any of their colleagues who may also be participants in this study.

The data will be stored securely on a password protected database for six years after completion of the study.

The study will be conducted according to the principles of the Declaration of Helsinki (12) and the South African Guidelines for Good Clinical Practice (13).

3.5 Research methodology

3.5.1 Research design

A prospective, exploratory and instrumental research design will be followed in this study.

A prospective study is one where the population is identified and followed up over a period of time and variables are measured at the time of conducting the study (14). This is a prospective study because the population will be identified, and data will be collected as the study progresses.

This study is exploratory in nature since it aims at exploring and describing phenomena (15). This approach was chosen to generate knowledge on comprehensive ECG diagnoses and findings, a phenomenon that has not been previously researched extensively.

This study is instrumental since specific rules, as proposed by Lynn's model (11), will be applied to develop a list to guide anaesthetists' knowledge.

3.5.2 Study method

The study method will use Lynn's Model which is a two-stage process to determine the content validity of a list of essential ECG knowledge for anaesthetists. These stages are the Development Stage and the Judgement/Quantification Stage.

3.5.3 Study population

The study population will consist of South African expert anaesthesiologists who are FCA(SA) Part II examiners.

3.5.4 Study sample and sample method

Development Stage

The sample for the Development Stage will consist of a minimum of five local experts from Johannesburg who are involved in training of registrars and affiliated to the University of the Witwatersrand Department of Anaesthesiology. The experts must have agreed to take part and should be FCA(SA) Part II examiners. The expert must be able to attend a Peer Group Discussion for this purpose.

Judgement/Quantification Stage

The sample for the Judgement/Quantification Stage will consist of South African anaesthesiology experts but will exclude those who participated in the Development Stage. The participants must be examiners for the FCA(SA) Part II examination and affiliated to any South African medical university department of anaesthesiology where the training of anaesthesiology registrars take place.

In this study a purposive sampling method will be used. Purposive sampling is a type of non-probability sampling (14). The researcher will identify experts who will suit the requirements of the study. In this study it will be experts with specific knowledge and expertise.

When using Lynn's Model for content validity, the sample size depends on the number of accessible, available and agreeable experts that the researcher can identify (11). A minimum of five experts would provide control for chance agreement. Lynn (11) has not established a maximum number of experts but it is unlikely to exceed 10. For this study, experts will be purposively selected and invited by the researcher and supervisors until atleast 10 responses are obtained.

3.5.5 Data collection process

Development Stage

The Development Stage consists of three steps namely domain identification, item generation and item formation (11). Domain identification will be conducted by performing a literature review. Item generation will be compiled from the literature

and item formation will be achieved by conducting a peer group discussion to debate the provisional list.

Sixteen experts will be invited to participate in the peer group discussion which will be held on a Wednesday after a departmental academic meeting. The experts will be e-mailed information letters (Appendix 1) and invitations to participate. If the experts are willing to participate, they will receive the provisional list with further instructions.

The aim of the peer group discussion will be to refine the provisional list and if necessary, make recommendations for changes, additions or deletions to the list to enhance content validity.

During the peer group discussion, the experts will be expected to review and grade the items on the list according to the following scale:

- 1. Do not need to know
- 2. Nice to know but not necessary
- 3. Should know
- 4. Must know.

The peer group discussion will be conducted by the researcher and each item of the list will be debated until 100% consensus is reached.

On completion of the peer group discussion, the necessary changes according to the peer group discussion will be made to the list and the list will be prepared for the Judgement/Quantification Stage. The list, at this stage, will be given to two participants of the peer group to verify that the recommended changes have been made.

Data analysis

Data analysis is not necessary for this stage as each item is debated until agreement is reached.

Judgement/Quantification Stage

The quantification stage of Lynn's Model has two steps. The first is the assertion by a specific number of experts that the items of the list are content valid. The second step is the assertion that the entire list is content valid (11).

Lynn (11) states that the quantification of content validity can be achieved with the content validity index (CVI). The CVI is derived from the rating of the content importance of the items using an ordinal rating scale. A four-point rating scale is preferable because it does not include the ambivalent middle rating common in odd number rating scales. The same rating scale that was used in the Development Stage will be used here.

The experts identified for the Judgement/Quantification Stage will be contacted telephonically or by email and then upon agreeing, will be emailed an information letter (Appendix 2) and the list produced after the peer group discussion and will be asked to rate it on the same scale as in the Development Stage.

The researcher will enter the data collected during this stage into a Microsoft Office Excel® spreadsheet.

Data analysis

The CVI for each item will be determined by the proportion of experts who rated it as content valid with a rating of three or four on the rating scale. Lynn (11) makes use of the cumulative binomial distribution to determine the proportion of experts needed to rate an item as valid. The cumulative binomial is published as standard norms (16) (Appendix 3). The CVI of the entire list is the total proportion of items judged as content valid.

3.6 Significance of the study

The ECG is a useful investigation preoperatively and an important monitor intraoperatively, therefore it is important that an anaesthesiologist be proficient in the interpretation. The minimum required knowledge of ECGs is not comprehensively defined by the College of Anaesthetists of South Africa and

therefore it would be beneficial to develop a list of essential ECG knowledge for an anaesthetist.

This list would be beneficial for the practicing anaesthetist/anaesthesiologist in maintaining clinical competence, the trainee anaesthetist in obtaining competence, and the academic staff in teaching the registrars and medical officers in the Department of Anaesthesiology of the University of the Witwatersrand.

3.7 Validity and reliability of the study

Validity refers to the degree to which a measurement represents a true value and reliability is the consistency of the measure achieved (17).

The validity and reliability of this study will be maintained by:

- using an appropriate study design
- using a validated model to develop the list
- giving participants specific instructions for contributing to the study
- all data entered into the Microsoft Office Excel® spreadsheet will be checked for accuracy.

3.8 Potential limitations

This study will rely on the response and participation of the experts who are invited. A poor response to the invitation may pose a potential limitation.

3.9 Project outline

3.9.1 Time frame

Activity	May 2018	June 2018	July 2018	Aug 2018	Sep 2018	Oct 2018	Nov 2018	Dec 2018	Jan 2019
Proposal									
Proposal submission									

Ethics and post grad approval									
Data collection									
Data analysis									
Article preparation									
Submission									

3.9.2 Financial Plan

Description	**Price per item**	**Number of items**	**Total**
Printing	R1	1000	R1000
Binding	R50	4	R200
Total			R1200

The Department of Anaesthesiology will bear the cost of printing and paper for the proposal, ethics and post graduate applications.

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3.11 Appendices

Appendix 1: Information letter for the experts in the Developmental Stage

Dr Mariam Moosa

Anaesthesiology Registrar

University of Witwatersrand

To: Dr/Prof

Dear Colleague

Hello, my name is Mariam Moosa. I am a registrar in the Department of Anaesthesiology at the University of the Witwatersrand. I am conducting a research study titled: **Development of a list of the essential electrocardiogram knowledge for anaesthesiologists** as part of my M Med degree.

This study is motivated by the fact that registrars in anaesthesiology do not have clear guidelines on obtaining and maintaining clinical competence in interpreting ECGs which is a necessary skill in our discipline.

I will be using Lynn's Model[1] to develop and validate this concept instrument. This is a two-stage (Development and Judgement/Quantification) process that is used to determine the content validity of a list.

I hereby invite you as an expert in anaesthesiology to be part of the peer group discussion for the Development Stage of this concept list. If you consent, I will send you documentation pertaining to the study prior to the peer group discussion.

This will include the provisional list with items, that I will have developed from reviewing the literature, for you to refine to ultimately enhance the content validity. During the peer group discussion, I will ask you to make recommendation for

[1] Lynn MR. Determination and quantification of content validity. Nurs Res.1986;35(6):382-5. doi:10.1097/00006199-198611000-00017.

changes, additions or deletions to the provisional instrument, and grade the items on a four-point scale:

- 1. Do not need to know
- 2. Nice to know but not necessary
- 3. Should know
- 4. Must know.

We will debate each item and items that reach a 100% consensus will then be prepared for the Judgement/Quantification stage.

Participation in this process is entirely voluntary. Participants will be requested to maintain confidentiality of what is discussed, but I as the researcher, cannot guarantee that this will be adhered to.

I appreciate that you will not benefit from participation in this study, however I hope that the development of a list of essential ECG knowledge for anaesthesiologists will contribute to the continuing professional development of all anaesthetists and will be invaluable in the training of junior anaesthetists and the maintenance of the skills of the anaesthetist in practice.

The study has been approved by the Human Research Ethics Committee (HREC) and the Graduate Studies Committee, University of the Witwatersrand.

Should you require any further information, you can contact:

- Me, Mariam Moosa cell: 0724786995. e-mail: mariammoosa5@gmail.com
- The chairman of the HREC (medical) Chairperson -Prof Clement Penny 0117172301.

Thank you for taking time to read this information letter.

Yours sincerely,

Mariam Moosa

Appendix 2: Information Letter for experts invited to the Judgement/Quantification stage

Dr Mariam Moosa

Anaesthesiology registrar

University of Witwatersrand

To: Dr/Prof

Dear Colleague

Hello, my name is Mariam Moosa. I am a registrar in the Department of Anaesthesiology at the University of the Witwatersrand. I am conducting a research study titled: **Development of a list of the essential electrocardiogram knowledge for anaesthesiologists** as part of my M Med degree.

This study is motivated by the fact that registrars in anaesthesiology do not have clear guidelines on obtaining and maintaining clinical competence in interpreting ECGs which is a necessary skill in our discipline.

I will be using Lynn's Model[2] to develop and validate this concept instrument. This is a two-stage (Development and Judgement/Quantification) process that is used to determine the content validity of a list.

I hereby invite you as an expert in anaesthesiology to be part of this study. Should you consent, I would like you to rate each item on this list and then the entire list on the following four-point scale:

[2]Lynn MR. Determination and quantification of content validity. Nurs Res.1986;35(6):382-5. doi:10.1097/00006199-198611000-00017.

- 1. Do not need to know
- 2. Nice to know but not necessary
- 3. Should know
- 4. Must know.

Participation in this process is entirely voluntary. I, the researcher, will be the only person knowing your identity and I will capture the data in a way that does not identify information of any participant, thereby ensuring confidentiality.

I appreciate that you will not benefit from participation in this study, however I hope that the development of a list of essential ECG knowledge for anaesthesiologists will contribute to the continuing professional development of all anaesthetists and will be invaluable in the training of junior anaesthetists and the maintenance of the skills of the anaesthetist in practice.

The study has been approved by the Human Research Ethics Committee (HREC) and the Graduate Studies Committee, University of the Witwatersrand.

Should you require any further information, you may contact:

- Me, Mariam Moosa cell: 0724786995 e-mail: mariammoosa5@gmail.com
- The chairman of the HREC (medical) Chairperson – Prof Clement Penny 0117172301

Thank you for taking time to read this information letter.

Yours sincerely,

Mariam Moosa

Appendix 3: The cumulative binomial distribution

Table 1: Table showing $CVR_{critical}$ one-tailed test (α= 0.05) based on exact binomial probabilities

N (panel size)	Proportion agreeing essential	$CVR_{critical}$ exact values	One-sided p-value	$N_{critical}$ (minimum number of experts required to agree item essential)- ****and ****, this paper	$N_{critical}$ calculated from CRITBINOM function- Wilson et al (2012)
5	1	1.00	.031	5	4
6	1	1.00	.016	6	5
7	1	1.00	.008	7	6
8	.875	.750	.035	7	6
9	.889	.778	.020	8	7
10	.900	.800	.011	9	8
11	.818	.636	.033	9	8
12	.833	.667	.019	10	9
13	.769	.538	.046	10	9
14	.786	.571	.029	11	10
15	.800	.600	.018	12	11
16	.750	.500	.038	12	11
17	.765	.529	.025	13	12
18	.722	.444	.048	13	12
19	.737	.474	.032	14	13
20	.750	.500	.021	15	14
21	.714	.429	.039	15	14
22	.727	.455	.026	16	15
23	.696	.391	.047	16	15
24	.708	.417	.032	17	16
25	.720	.440	.022	18	17
26	.692	.385	.038	18	17
27	.704	.407	.026	19	18
28	.679	.357	.044	19	18
29	.690	.379	.031	20	19
30	.667	.333	.049	20	19
31	.677	.355	.035	21	20
32	.688	.375	.025	22	21
33	.667	.333	.040	22	21
34	.676	.353	.029	23	22
35	.657	.314	.045	23	22
36	.667	.333	.033	24	23
37	.649	.297	.049	24	23
38	.658	.316	.036	25	24
39	.667	.333	.027	26	25
40	.650	.300	.040	26	25

Figure 1 shows a comparison of $CVR_{critical}$ values from our exact binomial and normal approximation to the binomial calculations and those reported by Lawshe (1975) and Wilson et al (2012). Normal approximation using the continuity correction returned values equal to those reported in Lawshe (1975) for all given panel sizes of 10 and above other than a minor difference of 0.01 for a panel size of 13.

Section 4: Annexures

4.1 Ethics approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Drs M Moosa & F Lambat & Ms H Perrie

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M180604

NAME: (Principal Investigator)	Drs M Moosa & F Lambat & Ms H Perrie
DEPARTMENT:	School of Clinical Medicine Department of Anaesthesiology Medical School University
PROJECT TITLE:	Development of a list of the essential electro-cardiogram knowledge for anaesthesiologists
DATE CONSIDERED:	29/06/2018
DECISION:	Approved unconditionally
CONDITIONS:	Title changed 26/09/2018
SUPERVISOR:	Professor J Scribante
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	29/08/2018

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on 3rd floor, Phillip V Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.
I/We fully understand the conditions under which I am/we are authorised to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to resubmit to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date of the meeting when the study was initially reviewed. In this case, the study was initially reviewed in **June** and will therefore reports and re-certification will be due early in the month of **June** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

M.Moosa — Principal Investigator Signature

01/09/2018 — Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

4.2 Graduate studies approval

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

12 September 2018
Person No: 0601824W
PAG

Dr M Moosa
P O Box 13354
Laudium
0001
South Africa

Dear Dr Mariam Moosa

Master of Medicine in Anaesthesia: Approval of Title

We have pleasure in advising that your proposal entitled *Development of a list of the essential electrocardiogram knowledge for anaesthesiologists* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

4.3 Turnitin report

0601824w:mariam_turnitin_2.docx

ORIGINALITY REPORT

23%	8%	20%	11%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

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3	Catherine Patocka, Joel Turner, Jeffrey Wiseman. "What adult electrocardiogram (ECG) diagnoses and/or findings do residents in emergency medicine need to know?", CJEM, 2015 Publication	2%
4	www.jormazabal.com Internet Source	2%
5	Marcel D'eon. "The elusive content of the medical-school curriculum: a method to the madness", Medical Teacher, 12/1/2005 Publication	1%
6	www.science.gov Internet Source	1%
7	Kadish, A.H.. "ACC/AHA clinical competence	

4.4 Letter from supervisor accompanying Turnitin report



13 May 2020

The Chairperson
Graduate Studies Committee
Faculty of Health Sciences
University of the Witwatersrand

Dear Professor Papathanasopoulos

Re: M Med: **Development of a list of essential electrocardiogram knowledge for anaesthesiologists**

Dr Mariam Moosa, student number: 0601824, has submitted her research report to Turnitin, which revealed a similarity index of 23%. These similarities appear not to be plagiarism but mainly the use of common terminology and phrases specific to the topic of the research and the validation model used.

Yours sincerely,

Juan Scribante
Supervisor