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Development of an Anaesthetic Medication Knowledge Test for Pre-Graduating Nursing Students

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Abstract

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Background: An anaesthetic nurse provides continual assistance to the anaesthetist during the delivery, maintenance, and reversal of anaesthesia. Therefore, it is important that nurses are clinically competent and possesses the knowledge base of pharmacodynamics and pharmacokinetics of medicines used in anaesthesia.

Purpose and aim: The purpose of this Bachelor's Thesis was to develop a knowledge test for pre-graduating nursing students on medicines used in anaesthesia. The aim for the Bachelor's Thesis was to develop a knowledge test that could be used as a teaching and evaluation tool in Metropolia University of Applied Sciences (UAS) in Finland to test and improve the pre-graduating nursing students' level of anaesthetic pharmacology knowledge.

Method: Delphi method was utilised during the development phase of this knowledge test. The panel of experts consisted of perioperative nursing teachers from Metropolia UAS, and the assessment consisted of two rounds. For the validation process, an expert panel was asked to validate the instrument through a content validity index method (CVI). Finally, the knowledge test was piloted to a group of pre-graduating nursing students from Metropolia UAS.

Results: The first round of testing included 51 multiple-choice questions. Based on the scores and feedback from the panellists, 22 questions were approved without changes, 26 questions were revised, and three questions were eliminated. Based on the recommendation from the experts, 14 new questions were developed. For the second round of assessment, the edited questions were sent to the expert panellists for final approval. This totalled to 40 questions out of which 32 questions were approved without changes and seven questions were to be revised. One question was eliminated based on feedback and low I-CVI score. One new question was developed. Total of 62 questions were included in the pilot group.

Conclusion: Based on the results of the assessment process, the knowledge test could be utilised in nursing education to examine and measure competence on medicines used in anaesthesia. It could also be used as an education tool to enhance learning.

Keywords	anaesthesia, medication, knowledge test, pre-graduating nursing students

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Tausta: Anestesiahoitaja avustaa anestesialääkäriä nukutuksen aloitusvaiheessa, ylläpitovaiheessa, sekä kumoamisvaiheessa. Siksi on tärkeää, että sairaanhoitaja hallitsee tarvittavat kliiniset taidot sekä omaa tarvittavan tiedon anestesiassa käytettyjen lääkkeiden farmakodynamiikasta ja farmakokinetiikasta.

Tarkoitus: Opinnäytetyön tarkoituksena oli kehittää tietotesti anestesiassa käytettävistä lääkkeistä vastavalmistuville sairaanhoitajaopiskelijoille. Tavoite oli, että tietotestiä voisi käyttää opetus- ja arviointityökaluna Metropolia ammattikorkeakoulun (AMK) opetuksessa. Sillä pyrittiin myös parantamaan vastavalmistuvien sairaanhoitajaopiskelijoiden tietämystä anestesiassa käytettävistä lääkkeistä.

Menetelmä: Delphi menetelmää käytettiin tietotestin kehitysvaiheessa. Asiantuntijapaneeli koostui Metropolia AMK:n perioperatiivisen sairaanhoitotyön opettajista, ja arviointiprosessiin sisältyi kaksi kierrosta. Validointiprosessissa asiantuntijapaneelia pyydettiin arvioimaan tietotestin kysymykset sisältövaliditeetti-indeksi menetelmän (CVI) mukaisesti. Lopuksi tietotestiä kokeilivat testiryhmä Metropolia AMK:n vastavalmistuvia sairaanhoitajaopiskelijoita.

Tulokset: Ensimmäiseen arviointikierrokseen sisältyi 51 monivalintakysymystä. Arviointitulosten ja asiantuntijapanelistien kommenttien perusteella 22 kysymystä hyväksyttiin ilman muutoksia, 26 kysymystä muokattiin, ja kolme kysymystä poistettiin. Asiantuntijoiden suositusten perusteella laadittiin 14 uutta kysymystä. Toisella arviointikierroksella yhteensä 40 kysymystä lähetettiin asiantuntijapaneelille viimeistä hyväksyntää varten. Kysymyksistä 32 hyväksyttiin ilman muutoksia, ja seitsemää kysymystä muokattiin. Yksi kysymys poistettiin, ja yksi uusi kysymys laadittiin. Yhteensä 62 kysymystä pääsi testiryhmän kokeiluun.

Pohdinta: Tulosten perusteella on mahdollista, että tietotestiä voisi käyttää vastavalmistuvien sairaanhoitajaopiskelijoiden anestesiassa käytettävien lääkkeiden osaamisen arviointi- ja mittausvälineenä. Sitä voisi myös hyödyntää työkaluna oppimisen edistämisessä.

Avainsanat	anestesia, lääke, tietotesti, valmistuva sairaanhoitaja opiskelija

Contents

1 Introduction

Discovery of anaesthesia has made much of today's surgery possible and has benefited patients throughout the years by blocking pain signals from nerves to the brain. Although modern anaesthesia is considered very safe and can be tailored to a patients' individual needs and to the type of surgery, the risk of complications persists. (NHS 2021). Surgical theatres and other perioperative areas are medication-intensive settings and most surgical procedures require some form of anaesthesia. Because of working closely and collaboratively with the anaesthetist, nurses must be familiar with the principles associated with anaesthesia and the medicines involved. (Criscitelli 2014.) However, anaesthesia pharmacology knowledge among nursing students has been shown to be limited at the time of graduation (Jeon, Ritmala-Castrén, Meretoja, Vahlberg & Leino-Kilpi 2020).

Nurses are frequently blamed for the high rates of medicine errors, which are associated with knowledge-based factors amongst others (Caboral-Stevens, Ignacio & Newberry 2020). The World Health Organisation (2017) estimates that the annual cost of medication errors reaches $42 billion USD globally and causes injury to approximately 1.3 million people every year in United States alone. All medication errors are potentially avoidable, and they are the single most important preventable factor for endangering patient safety.

To improve and measure the nursing students' level of anaesthetic competence, the purpose of this Bachelor's Thesis was to develop an anaesthetic medication knowledge test for pre-graduating nursing students. Knowledge tests can enhance students' ability to recall and retain information, as well as infer, analyse, evaluate, and apply the knowledge in different contexts. They also provide students with information about current knowledge and provide the means to test progress towards learning objectives. (Iowa State University 2022.) The knowledge test was requested by Metropolia University of Applied Sciences (UAS) in Finland to be utilised in their perioperative and critical care nursing education. To establish background for the Bachelor's Thesis, data was gathered about anaesthesia education, competencies, and assessment. A list of all commonly used medicines in general anaesthesia was devised and included in the appendixes, and it has been used as a basis for the questions in the knowledge test. The knowledge test comprises of multiple-choice questions and was designed to develop nursing students' competency and knowledge base of the topic. The questions were

assessed by an expert panel of teachers from Metropolia Nursing Degree programme, and after data analysis it was piloted to a group of pre-graduating nursing students from Metropolia UAS.

2 Role and competencies of an anaesthetic nurse

Surgical environments are technical and fast-paced areas that require critical thinking and immediate decision-making skills from the perioperative team to provide the best possible patient outcomes. Nurses working in these areas must possess the ability to think quickly and accurately, as well as advocate for the patient undergoing anaesthesia. This makes perioperative nursing a demanding and complex speciality, which requires unique skills and evidence-based knowledge. (Criscitelli 2014:17.)

Perioperative wards and surgical theatres are medication heavy areas, and many different medicines are used either alone, or in conjunction with others. In order to really understand anaesthesia, a knowledge of individual agents, their pharmacology and reasons for administration is important (Keat, Bate, Bown & Lanham 2012:88-89.) Patient safety must be maintained throughout any surgical or anaesthetic procedure. An anaesthetic nurse provides continual assistance to the anaesthetist during the delivery, maintenance, and reversal of anaesthesia. Therefore, it is important that the nurse is clinically competent and possesses the knowledge base of pharmacodynamics and pharmacokinetics of medicines used in anaesthesia. (Hughes & Mardell 2019:110.)

Recognising deterioration and being able to take appropriate action during anaesthesia management by demonstrating advanced knowledge is vital. Nurses must be competent in the use of anaesthesia agents as well as adjunctive and accessory medicines when providing anaesthesia care and pain management. Preparation, administration, and adaptation of anaesthetic medicines according to pre-existing diseases of the patient and surgical procedures are also included in core anaesthetic nursing skills. Nurses must follow the correct storage and handling methods of medicines as well as prepare medicines according to standard operating procedures, practice aseptic technique, and understand the importance of accurate documentation of any administered medicine. Anaesthetic nurses are also expected to be involved in developing and improving guidelines, standard operating procedures, and specifications for anaesthetic medicine use. (Stewart 2021.)

2.1 Competence development

Assessment is important in nursing education, as it can obtain information about students' learning, evaluation of competencies and clinical performance. This is particularly important in clinical practices, as students develop their skills and learn to think through a variety of clinical settings. Data about students' level of knowledge and ability are gathered to form assessments. Assessments provide information on whether the students are learning the key concepts of theory implementations and are they developing their clinical skills sufficiently. (Oermann and Gaberson 2019: 3.)

Common assessment strategies used by teachers to obtain information about student's learning and performance include tests or exams, written assignments, projects, small-group activities, presentations, e-portfolios, observations of performance, simulation-based assessments, and objective structured clinical examinations, among others. (Oermann and Gaberson 2019:4.)

2.2 Pharmacology competence amongst nursing students

Pharmacology knowledge is important for all nurses to ensure effective and safe patient care. The skills to prepare and administer medication safely involves knowledge application and critical thinking, which is underpinned by the pharmacological theory. For new graduating nurses, these skills are essential. (Freeling 2021.) To research what studies were found on pharmacology competence of nursing students, a PICO framework was created. A research question was formulated to guide the database search. The PICO framework and research question can be found in appendix 2. Guided by the PICO framework, a scoping search was performed from databases CINAHL, Pubmed and ProQuest Central. As the search concerning anaesthetic pharmacology knowledge of nursing students specifically yielded only one result, literature on general pharmacology knowledge of nursing students was accepted.

In Finland, anaesthesia care employers identified a gap between nursing education and practise, which prompted a cross-sectional survey design study to assess the anaesthesia nursing competence of nursing students, and to describe factors related to their anaesthesia nursing competence. A data was collected from 205 Finnish nursing students by using a survey in 2017, utilising 7 categories from the Anaesthesia Nursing Competence Scale. The assessment was based on self-assessment and used a Visual

Analogue Scale (0-100). Descriptive statistics, a Pearson correlation coefficient, independent sample t-tests and a multivariable regression were used to analyse the data. The results concluded that the self-assessed overall competence of graduating nursing students was an average at 59 (range 43-73). Approximately half of the students reached an acceptable level > 60 and half did not. The highest self-assessed category was collaboration within patient care, and the lowest was knowledge of anaesthesia patient care. The study findings suggest that current nursing education should focus on improving students' competence in patient risk care, and the knowledge of anaesthesia patient care by creating more opportunities for nursing students to practice anaesthesia nursing to develop their competence. The findings signify the importance of competence assessment, and that is necessary to measure whether nursing students have achieved the required competence to practice as anaesthesia care providers. (Jeon et al. 2020.)

Another study conducted in a nursing school in the United States investigated the risk of medicine error of undergraduate nursing students by assessing their level of knowledge. A Pharmacology Knowledge Questionnaire with was developed for this purpose, and the results from 147 participants were processed by using descriptive statistical analysis. The results showed that undergraduate nursing students have insufficient knowledge in pharmacology and evidence of increased risk of error was also found. Overall grade for the knowledge test was 60% matching similar results from other nursing students' pharmacology test scores worldwide. High risk factor was based on 14% of students who were very certain that their incorrect answers were correct. Based on the results there is a need to strengthen students' education in pharmacology knowledge. (Caboral-Stevens, Ignacio, & Newberry 2020.)

Nursing student' pharmacological knowledge and calculation skills were assessed by inviting bachelor's degree and diploma students from 29 participating schools from Belgium to complete a cross-sectional survey using the Medial Knowledge and Calculation test. The schools were also asked to provide information on their pharmacology curriculum. The curricula introduced portrayed large diversity in pharmacology. For example, a separate pharmacology module was offered in only one of the schools, whereas for the rest, pharmacology was completely integrated into other courses. Pharmacology lectures were delivered by a nurse, a pharmacist, or a physician. Only one of the nurse lectures had additional training in pharmacology. (Dilles, Vander Stichele, Van Bortel & Elseviers 2010.)

The test was divided into two sections: pharmacology and calculations. Mean scores of bachelor's degree students on the pharmacology section were 55% and 66% for calculations. Mean scores for diploma students were 52% and 53%. There was significant variation between schools. The study concluded that the pharmacological knowledge and calculation skills of the nursing students are limited immediately prior to graduation, and the students did not feel that they were ready to deliver safe medication care in practise. For example, there were several mistakes on the calculation test. The authors recommended that the schools would address these shortcomings, and that awareness would be needed regarding the newly graduated nurses' limitations. (Dilles et al. 2010.)

Pharmacological knowledge was also assessed in two other research articles. A Bachelor's Thesis investigating current knowledge and attitudes of Western Australian final semester registered nursing students towards patients' pain management concluded that nursing students are entering the profession lacking an adequate pharmacological knowledge base (Watkins 2018). Assessment of bachelor's and master's degree nursing students' knowledge of the medication management at intensive care units in Czech Republic similarly established that education in medicine management deserves much greater attention to ensure safety (Heczkova & Bulava 2018).

2.3 Perioperative and pharmacology education in undergraduate nursing studies in Finland

The Bachelor's degree in nursing offered by Metropolia University of Applied Sciences (UAS) in Finland is a 210-credit programme designed to fulfil the conditions of the European Union directive (2013/55/EU), which recognises the professional qualification for nurses. The curriculum consists of basic, professional, and elective studies. A Bachelor`s Thesis and supervised practice placements in clinical settings are also included in the studies. (Metropolia 2022.)

Evidence-based clinical nursing forms the basis of the nursing education enabling students to learn the clinical competences required in their future career. In addition to clinical placements, nursing students can practice their clinical and practical nursing skills in clinical laboratories and simulated learning environments. (Metropolia 2022.) The surgical and perioperative education included in the basic studies consists of 5 credits of theory and 8 credits of clinical practice. The theory covers all the main areas

of perioperative nursing, including introduction to anaesthesia pharmacology. Laboratory work and simulations are also included in theoretical studies, where students can familiarise themselves with the work of an anaesthetic nurse. Prerequisite for this implementation is the successful completion of Basics of Clinical Nursing competence, and basic knowledge of pharmacotherapy with successful completion of required drug calculation exams. The student has also an option to include surgical and perioperative nursing into their deepening studies. (Metropolia 2020.)

3 Principles of anaesthesia

Royal College of Anaesthetists (2022) describes anaesthesia as loss of sensation with or without loss of consciousness. Anaesthesia works by temporarily blocking the nerve signals that pass along from nerves to brain and it prevents patients from feeling pain during surgical procedures. In order to produce anaesthesia, medicines called anaesthetics are used. They are also given to relieve sensation and pain during surgery. Three main forms of anaesthesia include general anaesthesia, regional anaesthesia, and local anaesthesia. Local and regional anaesthetics allow patients to remain awake by numbing a part or parts of the body. General anaesthesia affects the whole body, making patients unconscious and unable to move. The type of anaesthesia used will depend on the type of surgery, patients' medical condition and several of other factors.

Regional anaesthesia is limited to a region of the body, such as lower half of the body or limb. Regional anaesthesia can be applied in either central, or peripheral techniques. Central techniques include epidural and spinal anaesthesia. Peripheral techniques include plexus blocks and single nerve blocks. Local anaesthesia affects only a small, localised area which is infiltrated by a local anaesthetic agent such as lidocaine. Local anaesthesia is usually applied by the operating surgeon during surgery to alleviate postoperative pain. (Goodman & Spry 2014: 269.) For the purpose of this Bachelor's Thesis, the focus was on medicines used in general anaesthesia.

General anaesthesia depresses the central nervous system. It is a medically induced state of unconsciousness, in which the patient's protective reflexes are obtunded and their physiological status is maintained and controlled by the anaesthesia provider. Components of general anaesthesia include amnesia, analgesia, and skeletal muscle relaxation. (Goodman & Spry 2014: 268.)

The combination of anaesthetic agents used for general anaesthesia makes the patient unarousable to tactile, verbal, and painful stimuli and the amnesia prevents them from remembering what happened. As a result of muscle paralysis, the patient is unable to maintain spontaneous ventilation and adequate airway protection. This necessitates the insertion of endotracheal tube to preserve airway patency with positive pressure ventilation. Secondary to stimulating or depressing effects of anaesthetic agents the patient's cardiovascular function may also become impaired. (Siddique & Kim 2022.)

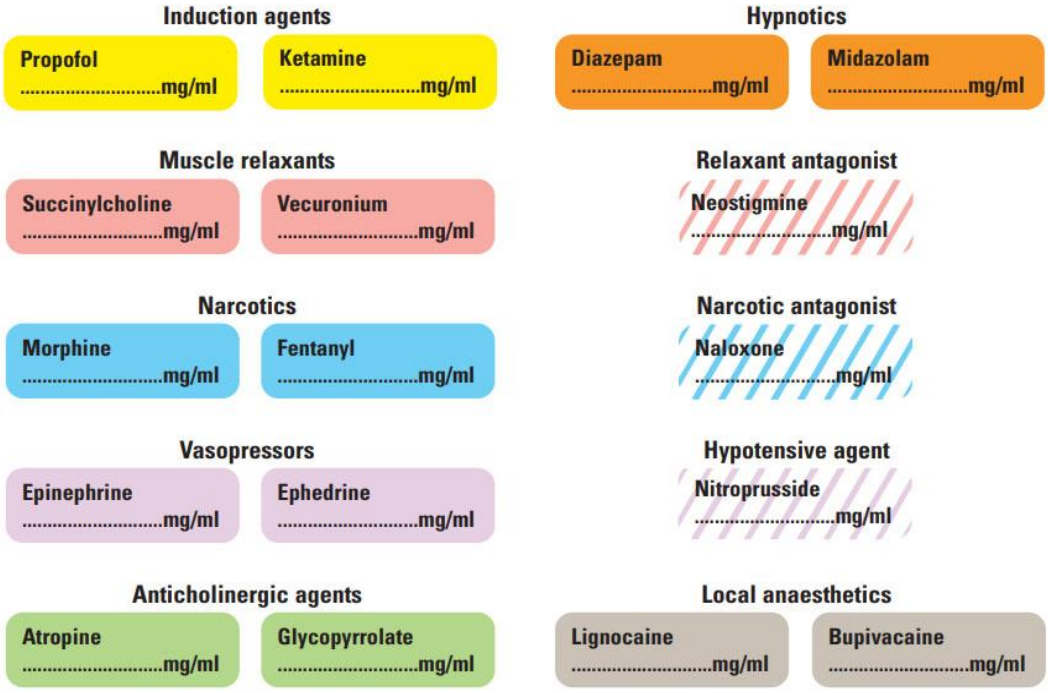
4 Medicines used in anaesthesia

Anaesthetic medicines are used to induce, maintain, and reverse anaesthesia. They are also used to eliminate pain and discomfort during and after surgery. They work by producing loss of consciousness, muscle relaxation and lack of response to pain. Medicines used to implement and support anaesthesia can therefore come under the following headings: induction agents, inhalation agents, muscle relaxants and analgesics. (Wicker 2015:28.) Anaesthesia medicines differ from most other branches of medicine, as they are usually given parenterally, either intravenously or via inhalation. In addition to their intended action, anaesthesia medicines can quickly produce intense physiological changes that may lead to serious undesirable effects. (Gwinnutt & Gwinnutt 2016:46.)

Anaesthetic medicines are labelled with internationally standardised colour labels to prevent medication errors and provide easy to use classification identification system for syringes. United Kingdom introduced the colour coded syringe labels in 2003 when the new standards for labels were introduced by The Royal College of Anaesthetists. Before adaptation in the UK, the standardisation already existed in Australia, New Zealand, and USA. (The Association of Anaesthetists 2021.)

The different coloured labels identify medicine groups or class, not individual agents. Blue labels are used to indicate narcotics, mainly opioids. Red labels are used for muscle relaxants, yellow for induction agents, violet for vasopressors, green for anticholinergics, orange for antiemetics and grey for local anaesthetic agents. (Niemi-Murola & Ahlmén-Laiho 2021.)

Figure 1. International Colour Coding System for Syringe Labelling (RCOA 2003).



4.1 Pre-anaesthesia medicines

Anxiolytic sedatives are used as pre-medication to encourage relaxation and alleviate anxiety. They are typically given pre-operatively to relax a patient before entering the operating room. Higher doses can be used to induce sleep. Anxiolytics may cause amnesia, where the patient does not remember the events following the administration of the medication. Examples of common sedatives used in anaesthetic settings are benzodiazepines, such as Midazolam, Diazepam, and Lorazepam. Midazolam is the most commonly used perioperative benzodiazepine. Sedatives can produce respiratory depression which can lead to apnoea, especially in elderly patients. In cases of suspected over-sedation or delayed emergence from general anaesthesia with suspected cause to be benzodiazepines, Flumazenil can be administered to reverse the effects. (Ehrenfeld, Urman & Segal 2010:40-41.)

4.2 Intravenous induction agents and inhalation anaesthetics

Intravenous induction agents are used to induce anaesthesia prior to the administration of inhalation agents. They can also be used as the sole anaesthetic by using total intravenous anaesthesia. Propofol is the most common intravenous general anaesthetic. It

has a rapid onset of action with fast recovery due to its short half-life. It can cause pain on injection especially on small hand veins, which can be alleviated with use of lidocaine. It also has antipruritic and anti-emetic properties and lowers the risk of postoperative nausea & vomiting. Propofol depresses the respiratory and cardiovascular systems and causes a marked decrease in blood pressure. Therefore, it is often avoided in hypotensive and hemodynamically unstable patients. Other induction agents such as Etomidate is considered safer for hemodynamically compromised patients. Ketamine, a dissociative anaesthetic agent is beneficial in hypovolemic trauma patients, as well in asthmatics due to bronchodilation and minimal effects on respiratory drive. (Ehrenfeld, Urman & Segal 2010:44-46.)

Volatile agents, or inhalation anaesthetics are common agents used for induction and maintenance of general anaesthesia. They produce a quick induction, can be rapidly titrated during anaesthesia, and are swiftly emerged at the conclusion of anaesthesia. Their effects can be reliably monitored with clinical signs, as well as end-tidal concentrations. Just a fraction of a volatile anaesthetic to the inspired oxygen results in a state of unconsciousness and amnesia. When combined with intravenous adjuvants, a balanced technique can be achieved. Sevoflurane, Desflurane, and Isoflurane are the most popular inhalational anaesthetics used in surgical theatres. They have many similarities in terms of the overall effects. They all cause a dose-dependent decrease in systemic blood pressure by decreasing systemic vascular resistance. Volatile agents also potentiate the actions of muscle relaxants and can trigger malignant hyperthermia in those who are susceptible. Sevoflurane is a low pungent gas, allowing a rapid induction without irritating the airway. Desflurane is a respiratory irritant and not used for induction of anaesthesia. (Barash, Cullen, Stoelting, Cahalan, Stock, Ortega, Sharar & Holt 2017.)

4.3 Analgesic pain medicines

Analgesic medicines are used to relieve pain and to reduce the reaction of the body to the surgery, as well as to provide post-operative pain relief. In anaesthetic setting a variety of analgesics are used, the majority of which are opioids. (Wicker 2015: 29-30). Short acting opioids such as Fentanyl and Sufentanil are beneficial for pain control during general anaesthesia. Longer acting opioids such as Morphine and Oxycodone are usually used for treatment of postoperative pain. Opioids come with several adverse effects, respiratory depression being a major one. Other adverse effects from opioids in-

clude bradycardia, miosis, and pruritus, as well as hypotension due to arterial and venous vasodilation, urinary retention, constipation, nausea, and vomiting. Naloxone is an opioid antagonist that can be used to reverse the effects of opioids, including respiratory depression. (Ehrenfeld, Urman & Segal 2010:43-44.)

Other common analgesics in perioperative settings include NSAIDS and paracetamol. They both have anti-pyretic properties and are widely used to relieve pain. However, frequent use of NSAIDs can account for many adverse side effects such as bleeding, renal impairment, and gastrointestinal perforation. (Stone 2014:37.)

4.4 Neuromuscular blocking drugs

Neuromuscular blocking drugs, also known as muscle relaxants, are medicines that induce complete relaxation of the muscles facilitating intubation and surgery. Muscle relaxants cause paralysis of all voluntary muscles, including muscles of respiration. A patient must be unconscious before their administration and ventilated afterwards, as they prevent spontaneous breathing. (Aegis Anesthesia 2022.) Muscle relaxants come in two forms, depolarising, and non-depolarising. They are differentiated based on their action at neuromuscular junction. Suxamethonium is the only depolarising agent in clinical use. It acts as an acetylcholine receptor agonist at the neuromuscular junction. It has the quickest onset of action, making it ideal for rapid sequence inductions. It also has the shortest duration of action, which is why it is almost exclusively used only to facilitate intubation, not for maintenance of relaxation. Suxamethonium increases serum potassium levels after administration, which is why use is contraindicated in burn patients, or in patients with hyperkalaemia. It is also contraindicated in patients with known or suspected risk of malignant hyperthermia. (Ehrenfeld, Urman & Segal 2010:47-49.)

Non-depolarising muscle relaxants work by competing with acetylcholine at the receptor sites in the neuromuscular junction, thereby inhibiting muscle contraction. Compared to Suxamethonium, they have a longer duration of action and are therefore used to maintain muscle relaxation during surgery, as well as to facilitate intubation. Some commonly used non-depolarising muscle relaxants are Rocuronium, Vecuronium, Pancuronium and Cisatracurium. Rocuronium has the fastest onset of action amongst the non-depolarizing muscle relaxants, and it can be used for rapid sequence induction if Suxamethonium is contraindicated. Benefits also include cardiovascular stability and minimal histamine release. (Stone & Fawcett 2014:34.)

Rocuronium is eliminated through liver, therefore it is contra-indicated in patients with hepatic disease. Cisatracurium doesn't require renal or hepatic elimination, which makes it a suitable agent for kidney and liver failure patients. Pancuronium is a long-acting muscle relaxant and mainly indicated in cardiac surgery, or situations where patient is not expected to be extubated at the end of surgery. (Goodman & Spry 2014:281.)

Reversal of residual neuromuscular blockade is usually required at the end of surgery, as residual weakness is very unpleasant for patients and puts them at post-operative risk of compromised breathing and airway protection. Neostigmine is the only commonly used anticholinesterase for this purpose. It causes marked bradycardia and therefore, is usually combined with an antimuscarinic medicine called Glycopyrrolate. Sugammadex can be used to reverse deep relaxation caused by Rocuronium and Vecuronium. It binds to them irreversibly, rendering them inactive. It has a role in failed intubation or ventilation scenarios by reversing muscle relaxation when rapid resumption of airway reflexes and respiratory function is required. (Stone & Fawcett 2014:34-35.)

4.5 Anticholinergic and vasoactive medicines

Anticholinergic medicines are frequently used perioperatively to counteract harmful cholinergic responses during anaesthesia, particularly bradycardia. Most common anticholinergics in use are Atropine and Glycopyrrolate. Unlike Glycopyrrolate, Atropine can cross the blood brain barrier, which in overdose situations can lead to central anticholinergic syndrome. Anticholinergics are also used to decrease secretions. This is particularly useful with patients who present with excessive salivation, which puts them at risk for aspiration. (Ehrenfeld, Urman & Segal 2010:50.)

Sympathomimetic medications are used to support cardiovascular system, particularly the blood pressure. Hypotension is the most common hemodynamic disruption requiring intraoperative treatment. Ephedrine is one commonly used vasopressor that has both alpha and beta receptor effects, which means it increases both blood pressure and pulse. It is useful for the treatment of acute decrease in blood pressure in patients with bradycardia. Repeated or prolonged use of Ephedrine depletes endogenous noradrenaline; therefore, it is administered in intravenous boluses, not as a continuous infusion. Ephedrine is also a bronchodilator and can be used in the treatment of bronchospasm. (Ehrenfeld, Urman, & Segal 2010:75-76.)

Noradrenaline is another frequently used sympathomimetic vasopressor and inotrope, which also acts on both alpha and beta receptors. It increases systemic vascular resistance, which leads to an increase in blood pressure. Noradrenaline must always be diluted in dextrose G5% or NaCl 0, 9% and can be administered either as a bolus or as a continuous infusion. Phenylephrine is a sympathomimetic medicine that only acts on alpha receptors, which increases blood pressure, but does not raise pulse. Instead, it can cause reflex bradycardia. It is especially indicated in patients who have a low blood pressure, with normal or high heart rate. (Ehrenfeld, Urman & Segal 2010:75-76.)

Hypertension is the most common avoidable medical reason for postponing elective surgeries. In the perioperative and postoperative period, hypertension can increase the risk of cardiovascular and cerebrovascular events, bleeding, and mortality. There are several different types of medicines used for treatment of perioperative hypertension, these include angiotensin converting enzyme (ACE) inhibitors, angiotensin receptor antagonists (ARA), calcium channel blockers as well as alpha- and beta blockers. While these medicines have multiple mechanisms of action, their predominant effect is to cause vasodilation. The chosen medicine usually depends on associated comorbidities. For example, beta-blockers such as Atenolol, Labetalol, and Propranolol are easy to use, relatively short acting and can positively affect the outcomes in patients with pre-existing coronary artery disease. (Jackson & Bellamy 2015.)

4.6 Antiemetics

Postoperative nausea and vomiting (PONV) is one of the most common postoperative complications and a leading cause of patient dissatisfaction. Anaesthesia and surgery can cause PONV in various mechanisms, and consequently there are many different medications available for prevention and treatment. Ondansetron is a commonly used serotonin antagonist, which can be given as a prophylactic before surgery in those who carry a moderate to high risk for developing PONV. Dexamethasone is a corticosteroid with antiemetic and anti-inflammatory effects, and it is frequently used with Ondansetron as a prophylactic measure. Droperidol is a highly effective antiemetic, but its use typically reserved for refractory nausea and vomiting due to its effects on QT prolongation. It also has sedative properties, especially in larger doses. (Ehrenfeld, Urman & Segal 2010:77-78.)

4.7 Antiarrhythmic and emergency medicines

General anaesthesia is associated with a number of complications, although serious complications to anaesthesia are rare. Anaesthetic agents can compromise ventilation, perfusion, cardiac output, as well as hypothalamic thermoregulation. The risk of complications is increased in obese patients, smokers and in patients with comorbidities. (Goodman & Spry 2014:262-263.) Anaesthetic emergencies occur suddenly, and they can quickly develop into life-threatening situations. Specific critical incident procedures have been created to help in the management of anaesthetic emergencies. When facing an emergency, advance understanding of anaesthetic pharmacology is a paramount skill of the anaesthetic nurse. Furthermore, all staff working in a surgical theatre should be knowledgeable of emergency medicines. (Allman & Wilson 2016:886.)

Anaphylaxis is a life-threatening condition that requires prompt recognition and treatment. Anaesthetic agents are potential triggers, particularly muscle relaxants, antibiotics, and colloids (Crabtree 2015.) Clinical symptoms of anaphylaxis include hypotension, tachycardia, arrhythmias, bronchospasm, hypoxemia, body swelling and rashes. Rapid treatment is crucial and includes removal of the triggering agent, adrenaline, hemodynamic support with fluids and vasopressors, intubation if airway not already secured, as well as steroids and antihistamines for supportive measures. (Ehrenfeld, Urman & Segal 2010:252.)

Laryngospasm is a life-threatening sudden closure of the vocal cords, which results in partial or complete loss of the patients' airway. It is a primitive protective airway reflex that exists to protect against pulmonary aspiration. Laryngospasm can rapidly result in hypoxia, hypoxaemia, and bradycardia. Laryngospasm can manifest as inspiratory stridor, see-saw abdominal and chest movements, or complete airway obstruction. Quick recognition and treatment are essential to re-establish ventilation and oxygenation as soon as possible to avoid morbidity and even death. Treatment requires removing the possible trigger, clearing the larynx, and applying continuous positive airway pressure with 100% oxygen, followed by deepening of anaesthesia with propofol. If propofol fails to relieve laryngospasm, paralysing with rapid acting muscle relaxant may be necessary. (Gavel & Walker 2014.) In Finland, intravenous lidocaine is the first line drug treatment of laryngospasm (Koivuranta, Leutola & Ala-Kokko 2002.)

Cardiac dysrhythmias are relatively common intraoperatively. Dysrhythmias during surgery can occur due to patients pre-existing physiological conditions, anaesthetic agents

or due to triggering factors from the surgery itself. Cardiac and thoracic surgeries have higher rates of dysrhythmias compared with other surgeries. Electrolyte imbalances, surgical stimulus, excessive vagal tone, rapid diuresis, hypovolemia, metabolic conditions, and hypoxemia amongst others can all cause varying degrees of dysrhythmias. Treatment focuses on identifying and managing the underlying causes. (Ehrenfeld, Urman & Segal 2010: 254-257.)

Cardiac arrest is a life-threatening event that requires immediate cardiopulmonary resuscitation. Adrenaline, a sympathomimetic amine and an alpha and beta-adrenoreceptors agonist is used as the first-line treatment for cardiac arrest, both shockable rhythms and asystole, as well as anaphylaxis. It is also used as a local vasoconstrictor and is frequently added to local anaesthetic solutions to prolong their duration of action. In resuscitation of adults, the dose of adrenaline is 1mg (1:10 000) intravenously or intraosseously as soon as possible, then every 3-5 minutes. In anaphylaxis, the treatment dose for adults is 0,5mg (1:1000) intramuscularly or 0, 05-0.1mg intravenously. (Kaukonen, Bendel, Hoppu, Kipinä, Koivula, Mononen & Sivula 2022:12-13.) Adrenaline may also be used as a low dose bolus or infusion to treat hypotension. However, titrating the balance between the alpha and beta receptor effects of adrenaline can be challenging, as individual responses to dose-related effects are variable. (London, Joshi, Mark, & Nussmeier 2022.)

Amiodarone is an antiarrhythmic agent used in the treatment of cardiac dysrhythmias, such as ventricular fibrillation, ventricular tachycardia, atrial fibrillation, and supraventricular tachycardia. In cardiac arrest situations, amiodarone is administered as a 300mg intravenous bolus after three shocks have been administered. Lidocaine is a rapid onset local anaesthetic amine, but it is also an antiarrhythmic agent particularly useful in treatment of ventricular arrhythmias. Intravenous Lidocaine 100mg may also be used in resuscitation, where amiodarone is not available. (Kaukonen et al. 2022:13-51, 45-46.)

4.8 Intravenous fluids

The human body contains about 60% of water by weight and it is partitioned in various compartments in the body, including extracellular and intracellular spaces. Many problems can occur during surgery and the post-operative period which are a direct result from fluid loss or fluid shift within the different compartments. Therefore, fluid management is one the most important roles anaesthesia nurses and anaesthesiologists have.

In perioperative areas, the evaluation and replacement of fluid status is an ongoing process. The goal is to support and maintain the volumes, compositions, and pressures of the various fluid compartments with appropriate choice of intravenous fluids, which can be categorised into two classes, crystalloids, and colloids. (Ehrenfeld, Urman & Segal 2010:199-202.) A table was created containing information on all common medicines used in anaesthesia which can be found at the end of this Bachelor's Thesis, in appendix 1.

5 Methodology and methods

5.1 Delphi method

Delphi method is a commonly used tool in health sciences, and the method is utilised when consensus needs to be found (Niederberger & Spranger 2020:1). In Delphi method, a group of 5-20 anonymous experts is formed, and they will provide unbiased assessment of the quality of the topic. Each expert member must be informed of the topic beforehand, and they are required to provide comments or reasons behind their judgement. This can lead to argumentation among the experts; however, it also allows Delphi participants to introduce new ideas into the discussion. (Greene, Armstrong & Graefe 2007.) The topic undergoes two to three rounds of assessment, and the test would be edited between each round based on the experts' feedback, until highest possible consensus has been reached. However, in health sciences, the use of expert opinions is considered inferior to evidence-based findings. (Niederberger & Spranger 2020: 1-2.) Delphi method was used during the development phase of this knowledge test. The panel of experts consisted of perioperative nursing teachers from Metropolia UAS, and the assessment consisted of two rounds. Finally, the knowledge test was piloted to a group of pre-graduating nursing students from Metropolia UAS. Student participation was voluntary, and their task was to give relevant feedback on clarity and relevancy of the questions in the knowledge test.

5.2 Purpose and aim

The purpose of this Bachelor's Thesis was to develop a knowledge test for pre-graduating nursing students on medicines used in anaesthesia. The aim for the Bachelor's

Thesis was to develop a knowledge test that could be used as a teaching and evaluation tool in Metropolia UAS to test and improve the pre-graduating nursing students' level of anaesthetic pharmacology knowledge.

5.3 Knowledge test development

The knowledge test development comprised of two phases: question construction and quantitative evidence in the form of validation process. Knowledge tests can be beneficial in assessing learning as they are quick to complete, relatively economical, and quantitative data received from the answers are normally easy to analyse (Bowling 2014:277). Knowledge tests are used to measure the outcomes of education, to monitor the learning process and to assess the content of education. Knowledge tests are also useful educational tools. (Kesänen, Leino-Kilpi, Arifulla, Siekkinen & Valkeapää 2013.) The basic assumption behind any knowledge test is that the designers understand the assumed level of knowledge of the respondent's and format the questions appropriately (Bowling 2014: 290).

The development process of the knowledge test followed the basic principles of questionnaire design. Special consideration was paid to question wording, form, and order, as they could influence the answers. (Bowling 2014: 290.) For this knowledge test, multiple-choice with four alternatives was chosen as question format. Tests with multiple-choice questions are an effective method to assess learning. Multiple-choice questions have many advantages as reliability and validity can be measured and quantified. They are also versatile, as multiple-choice questions can be designed to assess various levels of learning, such as basic recall, application, analysis, and evaluation. Students can generally answer multiple-choice questions quicker than for example essay type questions, accommodating a broader representation of course material. (Brame 2013.) Additionally, multiple-choice tests are efficient as they can be evaluated quickly, and with an automated online test the student is able to receive results and feedback immediately (Burton, Sudweeks, Merrill & Wood 1991).

Some speculation can be made on the results of the knowledge test, as multiple-choice questions are somewhat susceptible to guessing. By increasing the number of questions, the guessing factor can be reduced (Burton et al. 1991). Furthermore, multiple-choice questions are not the most effective in evaluating a student's ability to demonstrate thought process, articulate explanations, produce examples, or creative ideas as the students select their responses from a list of alternatives (Brame 2013; Burton et al.

1991). Also, psychological factors, such as motivation, physical factors, such as easy access to scientific sources, socio-economic factors, such as time available to study, and educational factors, such as previous exam success can have impact on the answers (Saravani, Haghighi & Abed-Saeedi 2013:38–39).

The questions were designed based on the information gathered in appendix 1 on medicines used in anaesthesia. The question pool for first round of assessment comprised of 51 multiple-choice questions. The questions were grouped under pre-medications and sedatives, induction agents, volatile agents, opioids and other pain medications, muscle relaxants, emergency medicines, sympathomimetics and vasoactive/-constricting medications, anticholinergic medicines, adrenoreceptor-blocking medicines, antiarrhythmic medicines, antiemetics, reversals and antidotes, as well as IV-fluids.

5.4 Question construction

During the question design process, many aspects needed to be taken into consideration to ensure valid and reliable results. Respondents could interpret the questions differently compared to the designers' intentions, and therefore care had to be taken when planning the questions. The questions had to be relevant to the topic, and ambiguity needed to be avoided, as for example the use of double negatives could have been unclear. Words that are short, simple, and familiar were used so that the questions were clear and easy to understand. Instructions on how to complete the knowledge test and timeframe were stated clearly. Also, the assessment of the test and the minimum score to pass was conveyed to the respondents. (Bowling 2014: 312-313.)

The key to obtaining the highest level of validity and reliability is good question construction. A multiple-choice question, also known as an item, consists of a stem and alternatives. A stem is the question or a problem to which the answer can be found from the alternatives. An effective stem is meaningful on its own and presents a definite problem related to the desired learning outcome. Irrelevant material in the stem can decrease the validity and reliability of the test scores. The stem should not be constructed negatively unless a significant learning outcome requires it. As students can have difficulty in understanding negative phrasing, the negative element should be highlighted clearly. (Brame 2013.)

The alternatives consist of the correct answer and incorrect alternatives, also called distractors. If there are more than one correct answer, this should be stated clearly. The purpose of the distractors is to entice those students who have not reached the required learning and therefore all the alternatives should be believable. The alternatives should be clear, concise, and mutually exclusive. Options “all of the above” and “none of the above” are not effective as by recognising more than one answer as correct or incorrect the students can use partial knowledge to reach to the correct conclusion. (Brame 2013.)

When constructing a test, emphasis is put on its reliability. A sufficient number of questions must be included to cover the content area tested. According to literature, the longer the exam is, the more reliable it is. Short exams with less questions are quick to execute, but less reliable. A few wrong answers on a short exam can have a significant effect on the overall scores, which results in potentially large measurement errors. On long exams a few wrong answers will not affect the results as much. However, long exams are more tiring for the students and consequently they may not respond seriously or accurately. (Clay & Root 2001.)

There are numerous different kinds of medications used in anaesthesia (Wicker 2015:28). In order to comprehensively cover all medications, the question pool would have been excessively large. Therefore, the focus was on the most commonly administered medications, as well as emergency medicines. Examples of some of the questions from the knowledge test can be seen in table 1.

Table 1. Examples of questions.

Question: Benzodiazepines such as Lorazepam and Midazolam are commonly used as... a) Antiemetics after surgery. b) Vasodepressors during invasive surgery. c) Anxiolytics and sedatives before or during surgery. d) Premedication to reduce post-operative pain.
Question: Opioid analgesics are commonly used during induction, maintenance, and recovery from general or regional anaesthesia. Which of the following statements are true in relation to opioid analgesics? a) Serious adverse symptoms of opioid analgesics include respiratory depression. b) Fentanyl has sedative effects. c) Remifentanil is often used as an only opioid due to its long duration of action. d) Tramadol must be administered as a rapid bolus via IV route.

Question: Malignant hyperthermia is the most dangerous side effect of general anaesthesia that can occur during surgery. Which drug is used to treat it?

a) Dantrolene
b) Glycopyrronium
c) Intralipid 20%
d) Naloxone

5.5 Validation process

Reliability and validity are important considerations when determining the usability of a knowledge test (Glasper & Rees 2016). Validity is defined as the extent to which any instrument measures what it is intended to. For this reason, in a development process a knowledge test goes through multiple iterations to ensure it is clearly worded, well defined, and covers topics important and relevant to anaesthesia pharmacology. Content validity measures how well items correspond or reflect to a specific domain and are measured using a quantitative technique. It can help to improve the instrument through achieving recommendations from an expert panel. If an instrument lacks content validity, it is impossible to establish reliability for it. For the validation process, an expert panel was asked to validate the instrument through a content validity index method (CVI). A content Validity Index is the most commonly used method to calculate content validity quantitatively (Rodriques 2017.)

Face validity can be explained as a test of internal validity, which requires investigators to step outside of their current research context and assess their observations from a common-sense perspective. This normally occurs when researchers obtain assessment from the individuals who will be affected by the research findings. (Gaber 2010.) In this research, the face validity of the knowledge test was evaluated by a pilot group of 18 graduating nursing students from Metropolia UAS. Participants were requested to provide feedback and request improvements. Comments were then assessed and discussed by the research team until consensus was reached and a final version of the instrument was established.

5.5.1 Content Validity Index

Content Validity Index for each item, i.e., question (I-CVI) is a method used to quantify the extent of agreement between two members of an expert panel. Analysing content

validity is a crucial step in knowledge test development. It links the abstract concepts to visible and measurable results. In a quantitative content validity method, the content of the knowledge test questions is quantified by using content validity index for each item. This indicates the relevancy and clarity of each question by measuring the proportion of agreement between the expert panellists. The results can range from zero to one. (Zamanzadeh, Ghahramanian, Rassouli, Abbaszadeh, Alavi-Majd & Nikanfar 2015.) Perfect CVI score is 1.0, and a score of 0.5 or less indicates and unacceptable level of content validity (Waltz, Strickland & Lenz 2010).

5.5.2 Expert panel

The content of the knowledge test was assessed and validated by an expert panel of two teachers proficient in perioperative nursing education from Metropolia University of Applied Sciences. Requirements for the members of the panel were subject matter expertise as well as sufficient skills in English language. The expert panel were asked to participate in two rounds of testing, and they were provided with instructions on how to complete their assessment. For both rounds of testing, the expert panel were asked to assess the relevancy of the questions to the content addressed and to judge the clarity of the questions.

5.5.3 Pilot group

After the knowledge test was approved by the expert panel, it was be piloted to a group of 18 pre-graduating nursing students from Metropolia UAS. The main purpose of the pilot test was to receive feedback from the pilot group. Participation in the pilot test was voluntary. The participating students had recently completed deepening theoretical studies in emergency and intensive care, and perioperative nursing. Both topics included tuition in pharmacology related to medicines used in anaesthesia. Prior to starting the test, the students were given appropriate instructions orally on how to answer the questions, i.e., one correct answer per question. The students were also advised to consider relevancy and clarity of the questions. A paper copy of the knowledge test was then handed to the students. Pass rate for the knowledge test was >50 % correct. The grading was: fail=<50 %, 1= 50-59 %, 2=60-69 %, 3= 70-79 %, 4=80-89 % and 5= 90–100 %. Upon completion of the knowledge test students were provided with correct answers and asked to provide feedback. Total time allocated for pilot test and feedback was 90 minutes. The pilot test and feedback were conducted anonymously, with no identifiable information of the participating students. Performance of the students was

not evaluated, but the data was used to assess whether the question was unclear, too simple, or too difficult. For example, if the students performed particularly poorly on one question, the research team was able to re-evaluate the question and make changes, if necessary.

5.5.4 Analysis of the results

The data from first and second round of expert panel feedback was analysed by using quality value index analysis for each individual item, i.e., question. To calculate I-CVI, the experts were asked to independently rate the relevance and clarity of each question by using a 4-point rating scale: 1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, 4 = very relevant, and for clarity: 1 = unclear, 2 = somewhat clear, 3 = quite clear, 4 = very clear. If the experts rated a question as 2 or 3 (somewhat/ quite relevant or somewhat/ quite clear) they were asked to provide a comment or suggestion for the changes required. I-CVI was then defined as the number of experts giving a rating or 3 or 4 (quite/ very relevant or quite/ very clear) for each question, divided by the number experts involved.

Tests and feedback forms were collected from the participating students upon completion of the pilot test. The test data was analysed and applied into a table form to highlight which questions were too simple, difficult, or unclear. Feedback was analysed and discussed with appropriate changes made, if required.

6 Reporting of results

6.1 First round

The first round of testing included the total pool of 51 multiple-choice questions. The expert panel were asked to consider if the questions met the objectives of the knowledge test by assessing the relevancy of the questions to the content addressed and to judge the clarity of the questions. I-CVI was calculated based on the assessment, and the results were interpreted as approved, revised and eliminated. The full table presenting the I-CVI results of the first expert panel assessment regarding relevancy and clarity can be found in appendix 3.

Based on the I-CVI calculations, in the first round of assessment, out of the total of 51 questions, 47 questions yielded the highest score of 1 in category relevancy, and 41 questions yielded the highest score of one in category clarity. In the same assessment, four questions received the score of 0, 5 in relevancy, and 9 questions received the score of 0, 5 in clarity. One question received the score of zero in clarity. The results of CVI calculations can be seen in table 2.

Table 2. Table Illustrating the total I-CVI numbers

Relevancy	Total (51)
CVI 1	47
CVI 0,5	4
CVI 0	0
Clarity	Total (51)
CVI 1	41
CVI 0,5	9
CVI 0	1

Based on the scores and feedback from the panellists, out of the total of 51 questions, 22 questions were approved without changes, 26 questions were revised, and three questions were eliminated. Based on the recommendation from the experts, 14 new questions were developed. Interpretation from the feedback can be seen in table 3.

Table 3. Table illustrating the interpretation of feedback

Interpretation	Amount (51)
Approved	22
Revised	26
Eliminated	3
New question	14

6.2 Second round

For the second round of assessment, the edited questions were sent to the expert panellists for final approval. This totalled 40 questions, out of which 26 were revised questions from first round and 14 were new questions. The expert panellists were provided with instructions on how to evaluate the questions. They were once again asked to assess relevancy in a scale of 1 = not relevant, 2 = somewhat relevant, 3 = quite relevant, 4 = very relevant, and clarity in a scale of 1 = unclear, 2 = somewhat clear, 3 = quite clear, 4 = very clear. If the experts rated a question as 2 or 3 (somewhat/ quite relevant or somewhat/ quite clear) they were asked to provide a comment or suggestion for the changes required.

Identically to the first round of assessment, the I-CVI was calculated based on the assessment, and the results were interpreted as approved, revised and eliminated. The table presenting the full I-CVI results of the second expert panel assessment regarding relevancy and clarity can be found in appendix 4.

Based on the I-CVI calculations in the second round of assessment, out of total of 40 questions, 35 questions yielded the highest score of one in category relevancy, and 37 questions yielded the highest score of one in category clarity. 4 questions received the score of 0, 5 in relevancy, and three questions received the score of 0, 5 in clarity. One question received the score of zero in relevancy. The results of CVI calculations can be seen in table 4.

Table 4. Table illustrating the total I-CVI numbers.

Relevancy	Total (40)
CVI 1	35
CVI 0,5	4
CVI 0	1
Clarity	Total (40)
CVI 1	37
CVI 0,5	3
CVI 0	0

Based on the scores and feedback from the panellists, out of the total of 40 questions, 32 questions were approved without changes and seven questions were to be revised. One question was eliminated based on feedback and low I-CVI score. One new question was developed based on feedback from the panellists. Interpretation from the feedback can be seen in table 5.

Table 5. Table illustrating the interpretation of feedback

Interpretation	Amount (40)
Approved	32
Revised	7
Eliminated	1
New question	1

6.3 Pilot test

Based on the pilot group feedback, the knowledge test was well received. Majority of the feedback regarding relevancy and clarity of the questions were encouraging and positive with some minor suggestions made. Some of the students highlighted that the knowledge test enhanced their learning, meaning it served an educational purpose as well. The negative feedback was mainly related to the length of test being too long. Some of the feedback gathered from the pilot test can be seen in table 6.

Table 6. Feedback from the pilot test students

"Questions covered all the necessary parts, particularly what we have been learning this semester. All questions were easy to understand. However, in some questions answers were revealed in the following question. I think question 21 should have come ahead of question 19. But otherwise, the test was well constructed and relevant"
"The questions were well put; few minor changes can be made. Most of them were thought in our lectures. I don't see any questions that are irrelevant."
"The questions were clear and precise. I've gained additional anaesthetic knowledge"
"Some of the medication included there are not familiar to me. The whole questionnaire is very helpful to evaluate the knowledge of a pre graduating nursing student."
"Overall nice test to generally let someone know what they know and what they need to learn more."
"Very nice that it was divided into different categories i.e., pre-medication, sedatives etc... Too many questions, at the end of the questions the level of concentration was getting down which meant that started making silly mistakes. Test was very professionally made".
"This is a clever way to evaluate graduating nurses' knowledge who intend to be an anaesthesia nurse. The questions were made professionally from reliable sources."

Out of the 62 questions in the pilot test, four questions received a 100 % pass rate followed by five questions receiving a score of 94 %. At the lower end, ten questions received a score of < 40 %. One question was eliminated based on low pass rate (28 %) and feedback indicating confusion regarding the answer choices. Five questions were revised, and upon review of all the feedback from the pilot group, no other actions were taken to make further changes to the questions. After the revisions were made, the questions totalled to 61 questions. A comprehensive table containing the pilot group test results can be found in appendix 5.

7 Discussion

Graduating nursing students are required to have skills to prepare and administer medication safely, which involves knowledge application and critical thinking, underpinned by pharmacological theory (Freeling 2021). The purpose of this Bachelor's Thesis was to develop an anaesthetic medication knowledge test for the pre-graduating nursing students. Even though the content area of the knowledge test was limited to medications used in anaesthesia, most of the medications covered are also applicable to acute and intensive care areas, making this beneficial to all graduating nurses, not just those specialising in perioperative care.

To build background for the knowledge test, a scoping search was conducted. Although literature regarding nursing students' anaesthesia medication knowledge at the time of graduation was limited, the search yielded some relevant studies. A study by Dilles et al (2010) concluded that the pharmacological knowledge and calculation skills of the nursing students are limited prior to graduation, and the students did not feel ready to deliver safe medication care in practise. The authors recommended that the schools would address these shortcomings. Similar results were highlighted in Finland, when anaesthesia care employers identified a gap between nursing education and practise, signifying the importance of competence assessment, and a means to measure whether nursing students have achieved the required competence to practice as anaesthesia care providers. (Jeon et al. 2020). Furthermore, an assessment of bachelor's and master's degree nursing students' knowledge of the medication management at intensive care units in Czech Republic established that education in medicine management deserves much greater attention to ensure safety. (Heczkova & Bulava 2018.)

For the theoretical background of the knowledge test, extensive data search was conducted to find reliable and current information on anaesthesia medicines from sources such as Akuuttihoidon lääkkeet, British national formulary (BNF), Oxford handbook of anaesthesia and Pharmaca Fennica. Information was compressed into a anaesthesia medication table (appendix 1), which contains the most commonly used medication in field of anaesthesia.

The knowledge test was validated by utilising the Delphi method. The content validity assessment consisted of two rounds of expert panel evaluations. Based on the results, quality value index for each question was calculated. The test was then piloted to a group of pre-graduating Metropolia UAS students who based on feedback, felt that the

knowledge test enhanced their learning and helped to further gain their anaesthetic medication knowledge. The students' feedback on relevancy and clarity stated that the questions in the knowledge test were considered both relevant and clear. When considering the feedback, the knowledge test could also benefit teachers, as it can monitor the learning process of students, measure the outcomes of education, and serve as an educational tool. The negative feedback from the pilot group test was mainly related to the length of test being too long. However, if the knowledge test is utilised in practise in the future, this issue can be solved with an automated question pool that randomly selects the required number of questions per test, instead of using all the questions.

With regards to limitations of this knowledge test, multiple choice questions can be prone to guessing. However, the likelihood of guessing was significantly reduced by developing a large question pool from which the questions could be randomly drawn from. Large question pool was also required to sufficiently cover the area. Despite the large number of questions, it can still be argued that not all aspects of anaesthetic pharmacology were included in the knowledge test.

7.1 Ethical considerations and validity

The fundamental principles of ethics in quantitative research are reliability, validity, bias, and rigour. Reliability in research refers to how accurately and consistently the tool of data collection has been performed. (Glasper & Rees 2016.) In this research proposal, only verified scientific sources were used for data collection, alongside publications from approved national governing bodies. The Bachelor's Thesis has been written according to Metropolia UAS guidelines for written assignments. All the work produced has been that of the authors, or appropriately referenced. Information gathered from sources have been presented without misinterpretation.

The validity of the knowledge test was be confirmed by performing content validity analysis. An informed verbal consent was acquired from all who participated in the validation process. Acquired data was processed and presented without manipulation or fabrication. Some questions can be raised regarding the reliability of the validation process. Commonly in Delphi method, a minimum of five anonymous experts are required to form a panel (Greene, Armstrong & Graefe 2007). However, the expert panel recruited to assess the validity of this knowledge test consisted of only two members, hence weakening the reliability. This was partly due to time constraints and strict

schedule. Additionally, the recruitment process proved to be difficult, as the requirements for the members of the panel included subject matter expertise as well as sufficient skills in English language. To ensure stronger test validity and reliability, the content validity assessment should be performed again before the knowledge test is applied into practice by using a bigger expert panel. More time should be allocated to recruit suitable experts for the panel, and the panellists should be provided with sufficient time to provide assessment.

Participation in the pilot test group was voluntary and feedback was provided anonymously. This enabled the students to be honest in their evaluations without fear of given feedback negatively impacting their reputations. As part of the pilot test, the students had to answer all 62 questions and provide feedback. Some psychological as well as physical factors could have influenced the pilot test as the students conducted the test in a busy classroom with limited time. This may have impacted on focus as the environment could have been a distraction to some students. It emerged in the feedback, that due to large volume of questions some students struggled with focus towards the end. Were the knowledge test included in the curriculum, the students would only be required to answer a reduced number of questions randomly drawn from the question pool. Although the students' answers were evaluated, the results were used to ascertain the success of question construction, rather than assess level of knowledge of the students.

7.2 Conclusion

After the content validity assessment and the pilot test, 61 questions were approved. Based on the results of the validation process, the knowledge test could be utilised in nursing education to examine and measure competence on medicines used in anaesthesia. It could also be used as an education tool to enhance learning. It is recommended that before the knowledge test is employed as part of an official curriculum the content validity analysis should be repeated by a larger group of expert panellists. Additionally, the test should be trialled in the format chosen for use. It was intended that the questions are suitable to be implemented into a digital platform, although they could also be used as a traditional pen and paper exam.

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Appendixes

Appendix 1: Anaesthesia medicine chart

CLASS	MEDICINE	INDICATION	SIDE-EFFECTS
SEDATIVES	**Midazolam** (Dormicum®)	A benzodiazepine with anxiolytic, muscle relaxant, anticonvulsant, sedative, hypnotic, and amnesic properties. Commonly used with spinal & other regional anaesthetics, induction and maintaining sedation in ICU. Most lipid soluble of the benzodiazepines → fastest onset. Onset P.O 10-30 minutes and I.V 1-3 minutes. Effect lasts approx. 1-2 hrs. If used as oral premedication, should be administered 45 min prior to surgery.	Hypotension, confusion, drowsiness, respiratory depression, muscle weakness, apnoea in large doses. In larger doses heavy sedation & amnesia. IV benzodiazepines are associated with cardiac and respiratory arrest if given too rapidly.
	Diazepam (Diapam® Stesolid®)	A long-acting benzodiazepine often used as pre-medication (P.O) for inducing sedation, anxiolysis, or amnesia before medical procedures or surgery. Onset of action in 30-90 minutes. Should be given approximately 1h prior to surgery. Has anticonvulsant, anxiolytic, sedative, and muscle-relaxing properties. May be used alone or in combination with other drugs for conscious sedation.	
	Lorazepam	A benzodiazepine used as a sedative and anxiolytic. Indicated as a premedication in adults to relieve anxiety or to produce sedation/amnesia. Has a slow onset and a long duration of action (8-10 h). Should be administered 90 min prior to surgery.	
INDUCTION AGENTS	**Propofol**	Short acting IV anaesthetic agent used for induction and maintenance of anaesthesia for adults and children > 1month. Onset of action 30-40 seconds. Duration of action 3-10 minutes → after infusion is stopped, patient should wake up in 5-10 min. Benefits include fast recovery and less PONV. Dose 1.5- 2.5 mg/kg at induction	Hypotension due to vasodilatation, coughing, apnoea, bradycardia in large doses, flushing and hyperventilation. Pain on injection especially small hand veins → lidocaine can be given. Contraindicated with allergies to eggs or soybeans.

	Ketamine	A dissociative IV anaesthetic used for induction and maintenance of anaesthesia. Indicated in septic, hypovolemic, high-risk patients and those with severe asthma. Unlike other anaesthetics, ketamine activates respiratory effort and promotes bronchodilation. Rapid onset of action and short acting with duration on effect only 5-15 minutes. Use of atropine or glycopyrrolate is indicated preoperatively as ketamine increases secretion production.	Increased respiratory rate. hallucinations, hypertension, tachycardia and PONV. In excessive doses, respiratory arrest may occur. Doses of over 0,5mg/kg can elevate entropy levels during anaesthesia. Contraindicated in hypertensive and stroke patients and those with increased ICP, intraocular pressure or pre-eclampsia.
	Etomidate	Rapid acting non-barbiturate anaesthetic (IV) with little effect on blood gases, ventilation, or the cardiovascular system. Used for induction of anaesthesia in high-risk patients. Safe cardiovascular risk profile → less likely to cause a significant drop in blood pressure than other induction agents.	Burning on injection, PONV and superficial thrombophlebitis (with rates higher than propofol). Causes adrenal suppression in larger doses.
	Thiopental	Thiopental is a rapid onset and short acting IV barbiturate used for induction of anaesthesia and anticonvulsant prior to the use of other general anaesthetic agents. Anaesthesia of choice for patients with high intracranial pressure or status epilepticus. Produces hypnosis within 30 to 40 seconds of injection. Recovery after a small dose is rapid, but repeated intravenous doses lead to prolonged anaesthesia because fatty tissues act as a reservoir → accumulation.	Hypotension, respiratory depression. Can cause apnoea, coughing, laryngospasm and bronchospasm.
VOLATILE AGENTS "Anaesthetic gases"	→ All following volatile agents decrease systemic blood pressure by decreasing systemic vascular resistance. They potentiate the actions of muscle relaxants and use of volatile anaesthetics or suxamethonium can trigger malignant hyperthermia in those who are susceptible.		
	Sevoflurane	Most commonly used inhalation anaesthetic agent used for induction and maintenance of general anaesthesia. Used in both adult and paediatric patients. Low pungency, allowing rapid induction without irritating the airway. Concentration for maintenance 0.5-3%.	Decrease in myocardial contractility and MAP → systolic decreases. Increases RR. Only little effect on pulse.

	Desflurane	A pungent inhalation anaesthetic used for maintenance of anaesthesia. Respiratory irritant → Not used for induction. Rapid onset and recovery due to low blood solubility. Concentration used for maintenance 2-6%.	Decrease in systemic vascular resistance and MAP. Irritant to respiratory tract → Can cause laryngospasm, coughing, increase in bronchial secretions.
	Isoflurane	An inhalation anaesthetic used for induction (rare) and maintenance of anaesthesia. Pungent gas → Irritant to the respiratory tract. Benefits of use fast recovery and less sensitization of the heart to catecholamines. Concentration for maintenance 0.5-3%.	Hepatotoxicity, produces dose-dependent hypotension due to peripheral vasodilation, decreases MAP. Irritant to the respiratory tract causing coughing and increase in bronchial secretions. Respiratory depressant.
OPIOIDS AND OTHER ANALGESICS	**Fentanyl**	Short-acting opioid analgesic used in anaesthesia during induction, maintenance, and recovery from general or regional anaesthesia. Also has sedative effects. Obtunds the cardiovascular responses to laryngoscopy and intubation. 50-80 times more potent than morphine. One of the most widely used opioids in intraoperative areas. Onset of action 2-5 min. Duration of action 30-60 min in small doses. Dose for induction 2-5 mcg/kg IV. Maintenance dose during longer procedures 1-2 mcg/kg every 30 to 45 minutes.	Respiratory depression causing decreased respiration rate and tidal volume. Miosis, bradycardia, nausea and vomiting, hypotension and chest wall rigidity. Diminishes ventilator response to hypoxia and hypercapnia. Minimal histamine release.
	Alfentanil (Rapifen®)	Short-acting opioid analgesic derivative of fentanyl. Obtunds cardiovascular responses to laryngoscopy and intubation. Effective as an analgesic during surgery and as an analgesic for critically ill patients. Fast onset, peak effect within 90 seconds. Duration of action 5-10 min. Produces an early peak analgesic effect and fast recovery of consciousness.	Respiratory depression, bradycardia, hypotension, miosis, sedative effects, nausea, nausea and vomiting. Minimal histamine release.
	Remifentanil (Ultiva ®)	A potent and ultra-short-acting synthetic opioid analgesic used during surgery for pain relief and adjunctive to an anaesthetic. Peak effect in 1-3 min. Duration of action 5-10 min (half-life 10-21 min). Usually given as an infusion. Not to be used as only opioid due to its short duration of action.	Respiratory depression, muscle rigidity, hypotension, bradycardia, nausea and vomiting. Minimal histamine release.

	Sufentanil (Sufenta®)	Very strong opioid used to induce and maintain anaesthesia, as an analgesic in labour and delivery and to treat severe, acute pain. 7-10 times as potent as Fentanyl. Onset of action within 1-3 min. Duration of action is dose dependant → 0,5 mcg/kg lasts for approx. 50 min.	Respiratory depression, muscle rigidity, bradycardia, hypotension. Minimal histamine release
	Oxycodone Oxanest ®)	Strong opioid analgesic. Commonly used in the management of moderate to severe post-operative pain. Onset of action IV within 5 min. Peak effect in 30 min. Duration of action 1-4 hrs. If administered IV titrated to desired effect every 5 min as a bolus. Typical post op instruction: 1mg/10kg/IM and 0.5mg/10kg/IV	Respiratory depression, nausea & vomiting, constipation, bronchoconstriction especially in asthmatics. Caution: drugs affecting CNS and in elderly.
	Morphine	A strong opioid analgesic used for treatment of moderate to severe acute and chronic pain. Not used in recovery in Finland. A potent analgesic, use is limited due to tolerance, withdrawal, and the risk of abuse.	Respiratory depression, nausea, vomiting, hypotension, bronchospasm, histamine release, constipation.
	Pethidine	An opioid agonist with analgesic and sedative properties used to manage severe pain and to treat postoperative shivering. Also used for intravenous regional anaesthesia, peripheral nerve blocks and intra-articular, epidural, and spinal analgesia. Widely used to relieve labour pain (UK). The onset of action in 5 minutes with peak effect in 30 minutes.	Respiratory depression, hypotension, nausea & vomiting, hallucinations, decreases gastric emptying. Sedation is less likely compared to other opioids.
	Tramadol	Synthetic and mild opioid analgesic. Must be administered slowly via IV route. → Causes nausea and vomiting if IV given rapidly. Considered a lower-risk opioid option for the treatment of moderate to severe pain due to good tolerability profile and multimodal mechanism of action.	Nausea and vomiting, dizziness, headache, sweating. Not for liver or renal failure patients. Precipitates when mixed with midazolam or diazepam. Potentiates the action of serotonergic medications → carries a risk of seizures and serotonin syndrome.
	NSAIDS Diclofenac® Voltarol ® Ketorolac®	Non-steroidal anti-inflammatory drugs are medicines that are widely used to relieve pain, reduce inflammation, and bring down a high temperature.	Caution in asthma, risk of renal impairment, risk of bleeding.

	Paracetamol	Widely used analgesic medicine used alone or in combination with opioids for pain management, as well as an antipyretic agent. Onset of action 5-10 min, peak effect in 1 hr, onset of effect 4-6 h. If administering IV, give the dose within 15 min. Typical dose per os: 1g x 3-4/day	Hepatotoxic medicine. Hypotension.
MUSCLE RELAXANTS	**Suxamethonium** (Sukolin®)	Only depolarising agent in clinical use. Used as a skeletal muscle relaxant to facilitate tracheal intubation and mechanical ventilation in emergency situations when rapid neuromuscular blockade is required. Causes muscle fasciculations. Rapid onset 30-60s and ultra-short duration of action (3-5 mins). Monitoring of neuromuscular function is recommended during infusion. Only administered IV. Dose 0.5-2.0 mg/ml.	Bradycardia, muscle aches, increased serum potassium (K+), increased intraocular pressure. Increased salivation and gastric secretions. Prolonged action may occur in burn patients, pregnancy, and patients with liver disease, cardiac or renal failure.
	Rocuronium (Esmeron®)	Commonly used skeletal muscle relaxant used to facilitate tracheal intubation and to relax skeletal muscles during surgery. Fast onset → Intubation time in 60 s. Can be used for rapid sequent induction where Suxamethonium is contraindicated.	Mild tachycardia and hypotension. Increased MAP. Decrease in intra-ocular pressure. Contraindicated or used with caution in patients with severe liver or renal problems.
	Vecuronium (Norcuron®)	Moderately acting skeletal muscle relaxant used to facilitate tracheal intubation, muscle relaxation in surgery or mechanical ventilation. No significant cardiovascular effects and minimal histamine release. Intubation time 90-120 s.	Lowest level of histamine release.
	Pancuronium (Pavulon®)	Long-acting muscle relaxant. Mainly indicated in cardiac surgery, or situations where patient is not expected to be extubated at the end of surgery. Intubation time in 90-120s or longer.	Increased heart rate and blood pressure due to vagal and sympathetic simulation.
	Cisatracurium (Nimbex®)	A skeletal muscle relaxant. Undergoes Hofman elimination and enzymatic ester hydrolosis → Indicated in patients with renal or hepatic disease. Intubation time in 120 s.	Skin redness or rash, bradycardia, hypotension, bronchospasm.

	Atracurium (Tracrium®)	A moderately acting muscle relaxant. Undergoes Hofman elimination and enzymatic ester hydrolosis → useful for severe renal or hepatic disease. Intubation time in 90 s.	
VASOACTIVE DRUGS	**Noradrenaline** 0.01-0.025 mcg/kg/min	Sympathomimetic vasoconstrictor and a positive inotrope. Stimulates peripheral vasoconstriction and dilation of coronary vessels increasing oxygen consumption. Used for emergency restoration of blood pressure in cases of acute hypotension. Administered through central vein to minimise the risk of extravasation (may cause tissue necrosis). It should be diluted as an infusion in G5% (5mg noradrenaline + G5% 250 ml = 0.02 mg/ml). Rapid onset of action and cleared quickly from plasma by combination of cellular reuptake and metabolism. Duration of action: 30-40min.	Anxiety, headache, photophobia, pallor, sweating, chest pain. Extravasation may lead to tissue necrosis. Blood pressure must be monitored during administration. Contraindicated in hypovolaemia, should be used with appropriate blood volume replacement.
	Phenylephrine	Sympathomimetic used to treat hypotension. Selectivity for alpha-receptors → causes vasoconstriction of blood vessels, which increases blood pressure, but not pulse. Instead, may cause reflex bradycardia.	Hypertension, reflex bradycardia, blurred vision, decreased peripheral circulation, agitation, chest pain, dyspnoea, nausea or vomiting, sweating.
	Ephedrine	Sympathomimetic with both alpha- and beta-adrenergic action used to treat hypotension and to increase pulse during anaesthesia. Safe in pregnancy as it maintains uterine and placental blood flow. Prolonged use depletes endogenous noradrenaline, therefore given as bolus doses, not as infusion. Typical bolus dose 2.5 to 5mg IV. Also a bronchodilator → can be used in treatment of bronchospasm.	Ventricular ectopy, tachycardia, angina, bronchodilation, hyperglycaemia due to anti-insulin effect.
	Etilefrine	Sympathomimetic adrenergic agonist used as an anti-hypotensive. Increases both blood pressure and pulse. Used as bolus doses to treat sudden cardiovascular collapse.	Dyspnoea, hyperglycaemia, sweating, weakness, tremors, cold extremities, hypokalaemia, tachycardia & arrhythmias.

ANTICOLINERGICS	**Atropine**	Anticholinergic drug used for treatment of bradycardia → increases heart rate. Can be used to reduce salivation and effects of vagal stimulations. Dose: 0.015-0.2 mg/kg (0.1 mg/10kg).	Decreased secretions, dry mouth, tachycardia, relaxes bronchial smooth muscle, confusion in elderly, urinary retention.
	Glycopyrrolate	Anticholinergic used for the treatment of bradycardia during anaesthesia. Reduces salivary secretions. Usually combined with neostigmine. Parasympatholytic → reduces the activity of parasympathetic nervous system. Peak effect 3 min after IV dose.	Dry mouth, inhibition of sweating, tachycardia, indigestion, headache, and dizziness. Due to anti-secretory action, should be administered with caution to a patient with fever.
ANTIEMETICS	**Droperidol**	Used for treatment and prevention of PONV. In large doses, also used as a tranquilizing and sedating agent.	Tachycardia. Possibility for extrapyramidal symptoms (rare). Risk of QT interval prolongation. Potentiates other CNS depressants.
	Metoclopramide	An antiemetic agent and dopamine D2 antagonist used in the treatment of gastroesophageal reflux disease, prevention of nausea and vomiting, and to stimulate gastric emptying. Short lasting (2.5-6h). Higher doses → more side-effects. 20mg as effective as 8mg Ondansetron	Drowsiness, dizziness, tiredness, agitation, headache, and diarrhoea. Frequent use can cause movement disorder tardive dyskinesia (TD)
	Ondansetron	A serotonin 5-HT3 receptor antagonist used for prevention and treatment of PONV. More effective than metoclopramide. Onset of IV: 30min, PO half-life 4h.	Constipation. Can lead to the prolongation of the QT interval → caution is advised in susceptible patients.
	Dexamethasone	A glucocorticoid used for prevention of PONV. Also used for treatment of cerebral oedema. Caution - acute rectal pain with IV administration.	Anxiety, headache, blurred vision, dizziness, numbness or tingling, cardiac rhythm changes.
REVERSALS & ANTIDOTES	**Neostigmine**	A cholinesterase inhibitor used to reverse the effects of muscle relaxants. Onset in 7-11 min. Duration of action approx. 60 minutes. Must not be administered until spontaneous recovery from relaxation has started due to risk of residual paralysis.	May cause bronchoconstriction, increased secretions & salivation. Bradycardia → Given together with glycopyrrolate.
	Sugammadex	A selective relaxant binding agent indicated for reversal of neuromuscular blockade induced by rocuronium and vecuronium. Should be administered as a single dose.	Not safe in renal impairment. Recurarization may occur.

	Naloxone	Pure opioid antagonist. Indicated for the emergency treatment of an opioid overdose or suspected opioid overdose. Duration of action: 45-90 min.	Inadequate pain control. Can produce rapid onset of opioid withdrawal symptoms if not carefully titrated to effect.
	Flumazenil	Reverses effects of Benzodiazepines**.** Rapid onset action, effects are usually seen within 1–2 min. Repeated doses may be required.	Headache, dizziness, nausea & vomiting, sweating, flushing, vision problems.
	Protamine	Reverses the action of heparin. Indicated in the treatment of heparin overdoses, or to counteract heparin used preoperatively or intraoperatively.	Sudden fall in blood pressure, bradycardia, hypertension, dyspnoea, flushing and warmth.
	Intralipid	Used for treatment of severe local anaesthetic toxicity (epidurals, spinals) especially in labour wards.	Headache, dizziness, flushing, drowsiness, nausea & vomiting, sweating.
	Dantrolene	Treatment for malignant hyperthermia.	Muscle weakness, dizziness, diarrhea and fatigue. Can cause severe liver damage.
EMERGENCY DRUGS	**Adrenaline** 1000 = 1mg/ml 10 000 = 0.1mg/ml (100mcg/ml).	A direct-acting sympathomimetic agent with both alpha (positive cardiac inotrope & vasoconstrictor) and beta (bronchodilator) action. Used in cardiac arrest situations and as inotropic support in the critically ill with circulatory failure (severe hypotension) by IV bolus or infusion and in anaphylaxis. Nebulised to decrease symptoms of acute upper airway obstruction and post-intubation swelling. Also used as an additive in regional and local anaesthesia to prolong the effect of the block. Rapid onset of action and quickly inactivated in the body mostly by liver enzymes. Administered IV, IM, IO or endotracheally.	Side-effects occur mainly due to the overstimulation of both alpha- and beta-adrenergic receptors and include hypertension, tachycardia, anxiety, hyperglycaemia, arrhythmias, reduces uterine blood flow. Prolongs the action of local and regional anaesthetics.
	Lidocaine	Rapid onset local anaesthetic amine. Used for treatment of laryngospasm and for ventricular arrhythmias in cardiac arrest if amiodarone is not available.	Local anaesthetic toxicity, cardiac arrest in overdose.
	Amiodarone	An antiarrhythmic drug used to treat life-threatening ventricular and supraventricular arrhythmias ventricular tachycardia and ventricular fibrillation. Increases the duration of action potential and refractory period in atrial and ventricular myocardium. If Lidocaine is given, Amiodarone should NOT be administered.	Hypotension, cardiovascular collapse, other arrythmias may arise in the presence of hypokalaemia, thyroid disfunction, reversible corneal deposits.

ANTIHYPER-TENSIVE MEDICATION	**Glyceryl trinitrate** (nitroglycerin)	A nitrate vasodilator used for treatment of hypertension, treatment or prevention of angina, to control heart failure in myocardial infarction and to induce hypotension intraoperatively. Causes vasodilation of both arteries and veins.	Headache, hypotension, hypovolemia. Contraindicated in hypovolemic patients → must be corrected before use.
	Beta-blockers Atenolol Labetalol Propranolol	Betablockers or beta-adrenergic blocking agents are used for treatment of hypertension. They reduce activity of the heart, causing it to beat with less force and more slowly. Betablockers also widen veins and arteries to improve blood flow. Labetalol is a commonly used betablocker during surgeries as a treatment of hypertension and hypertensive emergencies. It is also used to induce controlled hypotension during operations. Can be administered as IV boluses or infusion.	Hypotension, bradycardia, exacerbation of heart failure, swelling. Contraindicated in asthmatics.
	Clonidine	Alpha adrenergic agonist used for treatment of hypertension. Clonidine works by blocking the release of noradrenaline, which reduces the activity of sympathetic nervous system → lowering blood pressure as well as heart rate.	Hypotension, bradycardia, dry mouth and constipation.
	Phentolamine	An alpha-adrenergic antagonist used to reverse soft tissue anaesthesia, as well as in the treatment of severe hypertension and hypertensive emergencies. Also used for prevention and treatment of necrosis caused by noradrenaline and other sympathomimetic extravasation.	Tachycardia, hypotension, headache, dizziness and nausea.
DIURETICS	**Furosemide**	A fast onset loop diuretic used to treat hypertension and oedema in congestive heart failure, liver cirrhosis, renal disease, raised intracranial pressure and hypertension. Short duration of action has been used safely and effectively in both paediatric and adult patients. Infusion rate of more than 4mg/min should not be exceeded due to ototoxicity. Max dose in 24 h is 1000mg. Can cause acute renal failure and deafness when co-administered with aminoglycosides.	Hypokalaemia, hypocalcaemia, hypomagnesaemia, metabolic alkalosis, auditory nerve damage, skin rashes. Caution: Hourly urine output, potassium, and glucose must be monitored. Not to be given if hypokalaemia, hyponatraemia, anuria, or liver failure.

	Mannitol	Osmotic diuretic used for renal protection, reduction of intercranial pressure, treatment of rhabdomyolysis. Irritant to tissues and veins. Onset of action happens within a few minutes.	Side-effects include diuresis (1-3 hrs after administration) and possible fall of plasma potassium and sodium.
ELECTOLYTE IMBALANCES	**Potassium** (Kalium)	Used in treatment of hypokalaemia. Potassium must never be administered undiluted. Continuous ECG monitoring required in larger doses. **IV dose:** Peripheral line = 40 mmols diluted in 1000 mls. Safe rate 10 mmols per hour maximum. CV line = 20 mmols in 50-100mls. Safe rate 20 mmols per hour maximum.	Cardiac arrhythmias, peripheral irritation, thrombophlebitis. Doctor must be present if speed over 20 mmols per hour.
	Magnesium	Used for treatment of hypomagnesaemia, ventricular arrythmias. Also used for treatment of severe asthma attacks, constipation, indigestion, magnesium deficiency and pre-eclampsia. In acute situations can be given undiluted, but usually given as an infusion. In larger doses continuous ECG, respiratory rate and blood pressure monitoring.	Tiredness, muscle weakness, respiratory depression, ECG abnormalities. Cannot be given through the same infusion line with furosemide, diazepam, haloperidol or cefuroxime.
	Calcium chloride	Used for the treatment of hypocalcaemia and for the treatment of magnesium intoxication. Also used to combat the effects of hyperkalaemia.	Hypertension, arrythmias, hypercalcaemia. No to be given at the same time with bicarbonate.
	Sodium bicarbonate	Used for the correction of metabolic acidosis. ABG's required. Also is indicated in severe diarrhoea which is often accompanied by a significant loss of bicarbonate.	Alkalosis, hypokalaemia, hypernatremia.
OTHERS	**Steroids** Hydrocortisone	Glucocorticoids are used to treat corticosteroid-responsive dermatoses, endocrine disorders, immune conditions, anti-inflammatory effects, and allergic disorders.	Hypertension, Fluid retention, muscle weakness, and hyperglycaemia. Slow IV or IM injection.
	Antihistamines	Antihistamines are allergy medicines which are also as supportive treatment for anaphylactic reaction. May help counter histamine-mediated vasodilation and bronchoconstriction.	Drowsiness and dry mouth.

	Bronchodilators	Bronchodilators relax and open the airways, or bronchi in the lungs. Short-acting and long-acting bronchodilators treat various lung conditions. Common bronchodilators: Salbutamol (inhaled or IV), Ipratropium (inhaled), Aminophylline (IV).	Trembling, headaches, dry mouth, cough, palpitations, nausea.
	Insulin	Used to control hyperglycaemia in diabetes mellitus, ketoacidosis, and hyperkalaemia.	Hypoglycaemia and hypokalaemia.
	Glucagon	Used to treat hypoglycaemia in diabetes mellitus, beta-blocker overdose and as a part of gastrointestinal imaging procedures. Glucagon raises blood sugar through activation of hepatic glucagon receptors, stimulating glycogenolysis and the release of glucose. Has a short duration of action	Hypotension, hypertension, nausea and vomiting.
IV Fluids	**Crystalloids**	Used to replace smaller volume loss. Molecules are smaller, which can move around easily in the body. Fluids can be isotonic (Hartmanns, Ringer, NaCl 0.9%) or hypotonic (NaCl 0.33% +Gluc).	Fluid overload, increased risk of pulmonary oedema.
	Colloids	Plasma expanders used to replace lost volume. Must be used with caution. Colloids have bigger molecules, so they stay in the blood for longer before passing to other parts of the body.	Increased risk of anaphylactic reactions.

Appendix 1. references:

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Appendix 2: PICO- Framework

A PICO framework was used to help identify key search terms and to refine the research question.

PICO	Description of detail
Population	Pre-graduating nursing students
Intervention	Development of a knowledge test
Comparison	Non
Outcome	Increased knowledge on medicines used in anaesthesia

Key search terms:

Nurs*, student*, undergraduate, anaesthe*, drug*, pharmacology, medic*, knowledge, competence.

Boolean phrase:

Anaesthe* AND knowledge OR competence AND student* OR undergraduate AND nurs* AND drug* OR medic* OR pharmacology.

Research question:

What is the nursing students' level of anaesthetic pharmacology knowledge at the time of graduation?

Appendix 3: Content Validity Index (first round)

I-CVI results from first round of assessment

Item	Relevant (Rating 3/4)	Not relevant (Rating 1/2)	I-CVI	Clear (Rating 3/4)	Not clear (Rating 1/2)	I-CVI	Interpretation
1	2	0	1	2	0	1	Revised
2	2	0	1	1	1	0,5	Eliminated
3	2	0	1	2	0	1	Approved
4	1	1	0,5	2	0	1	Revised
5	2	0	1	2	0	1	Approved
6	2	0	1	2	0	1	Approved
7	2	0	1	1	1	0,5	Revised
8	2	0	1	1	1	0,5	Approved
9	2	0	1	1	1	0,5	Revised
10	2	0	1	2	0	1	Revised
11	2	0	1	1	1	0,5	Revised
12	2	0	1	2	0	1	Revised
13	2	0	1	2	0	1	Approved
14	1	1	0,5	2	0	1	Eliminated
15	2	0	1	1	1	0,5	Eliminated
16	1	1	0,5	2	0	1	Revised
17	2	0	1	1	1	0,5	Revised
18	2	0	1	0	0	0	Revised
19	2	0	1	2	0	1	Revised
20	2	0	1	2	0	1	Approved
21	2	0	1	2	0	1	Approved
22	2	0	1	2	0	1	Approved
23	2	0	1	2	0	1	Approved
24	2	0	1	2	0	1	Approved
25	2	0	1	2	0	1	Approved
26	2	0	1	2	0	1	Revised
27	2	0	1	2	0	1	Approved
28	2	0	1	2	0	1	Revised
29	2	0	1	2	0	1	Revised
30	2	0	1	2	0	1	Revised

31	2	0	1	2	0	1	Revised
32	2	0	1	2	0	1	Approved
33	2	0	1	2	0	1	Approved
34	2	0	1	2	0	1	Revised
35	2	0	1	2	0	1	Approved
36	2	0	1	1	1	0,5	Approved
37	2	0	1	2	0	1	Revised
38	2	0	1	2	0	1	Revised
39	2	0	1	2	0	1	Approved
40	2	0	1	2	0	1	Approved
41	2	0	1	2	0	1	Approved
42	2	0	1	2	0	1	Revised
43	2	0	1	2	0	1	Approved
44	2	0	1	2	0	1	Approved
45	2	0	1	2	0	1	Approved
46	2	0	1	2	0	1	Revised
47	1	1	0,5	2	0	1	Revised
48	2	0	1	2	0	1	Revised
49	2	0	1	2	0	1	Revised
50	2	0	1	2	0	1	Revised
51	2	0	1	1	1	0.5	Revised

Appendix 4: Content Validity Index (second round)

I-CVI results from second round of assessment

Item	Relevant (Rating 3/4)	Not relevant (Rating 1/2)	I-CVI	Clear (Rating 3/4)	Not clear (Rating 1/2)	I-CVI	Interpretation
1	2	0	1	2	0	1	Approved
2	2	0	1	2	0	1	Approved
3	2	0	1	2	0	1	Approved
4	1	1	0,5	2	0	1	Revised
5	2	0	1	2	0	1	Approved
6	2	0	1	2	0	1	Approved
7	2	0	1	2	0	1	Approved
8	2	0	1	2	0	1	Approved
9	2	0	1	2	0	1	Approved
10	2	0	1	2	0	1	Revised
11	2	0	1	2	0	1	Approved
12	2	0	1	2	0	1	Approved
13	2	0	1	2	0	1	Revised
14	2	0	1	2	0	1	Approved
15	2	0	1	1	1	0,5	Revised
16	2	0	1	2	0	1	Approved
17	2	0	1	2	0	1	Approved
18	0	2	0	2	0	1	Eliminated
19	2	0	1	2	0	1	Approved
20	2	0	1	2	0	1	Revised
21	2	0	1	2	0	1	Approved
22	2	0	1	2	0	1	Approved
23	2	0	1	2	0	1	Approved
24	2	0	1	2	0	1	Approved
25	2	0	1	1	1	0,5	Revised
26	2	0	1	2	0	1	Approved
27	2	0	1	2	0	1	Approved
28	2	0	1	2	0	1	Approved
29	2	0	1	2	0	1	Approved
30	2	0	1	1	1	0,5	Revised

31	2	0	1	2	0	1	Approved
32	2	0	1	2	0	1	Approved
33	2	0	1	2	0	1	Approved
34	2	0	1	2	0	1	Approved
35	1	1	0,5	2	0	1	Approved
36	1	1	0,5	2	0	1	Approved
37	2	0	1	2	0	1	Approved
38	2	0	1	2	0	1	Approved
39	1	1	0,5	2	0	1	Approved
40	2	0	1	2	0	1	Approved

Appendix 5: Results of pilot test

Results of the pilot group test

Item	Correct	Incorrect	Correct %	Interpretation
1	18	0	100	Approved
2	18	0	100	Approved
3	13	5	72	Approved
4	10	8	56	Approved
5	13	5	72	Approved
6	14	4	78	Approved
7	11	7	61	Approved
8	5	13	28	Approved
9	13	5	72	Approved
10	8	10	44	Approved
11	9	9	50	Approved
12	6	12	33	Approved
13	7	11	39	Approved
14	15	3	83	Approved
15	18	0	100	Approved
16	16	2	89	Approved
17	4	14	22	Revised
18	14	4	78	Approved
19	15	3	83	Approved
20	11	7	61	Approved
21	15	3	83	Approved
22	5	13	28	Approved
23	14	4	78	Approved
24	17	1	94	Approved
25	14	4	78	Approved
26	12	6	67	Approved
27	8	10	44	Approved
28	13	5	72	Approved
29	13	5	72	Approved
30	17	1	94	Approved
31	12	6	67	Approved
32	16	2	89	Approved
33	9	9	50	Approved
34	10	8	56	Approved

35	8	10	44	Approved
36	12	6	67	Approved
37	12	6	67	Approved
38	10	8	56	Approved
39	12	6	67	Revised
40	13	5	72	Approved
41	16	2	89	Revised
42	16	2	89	Approved
43	10	8	56	Approved
44	12	6	67	Approved
45	13	5	72	Approved
46	17	1	94	Approved
47	14	4	78	Approved
48	3	15	17	Eliminated
49	10	8	56	Approved
50	12	6	67	Approved
51	12	6	67	Approved
52	13	5	72	Approved
53	17	1	94	Approved
54	11	7	61	Approved
55	7	11	39	Revised
56	16	2	89	Approved
57	12	6	67	Approved
58	4	14	22	Approved
59	17	1	94	Approved
60	17	1	94	Approved
61	5	13	28	Approved
62	18	0	100	Revised