



Hadi Ali

# Postoperative Pain Assessment among Patients Undergoing Open Heart Surgeries

Descriptive Literature Review

Metropolia University of Applied Sciences

Degree Programme in Nursing

Bachelor's Thesis

20 March 2023

Author	Hadi Ali
Title	Postoperative Pain Assessment among Patients Undergoing Open Heart Surgeries
Number of Pages	22 pages + 1 appendices
Date	20 March 2023
Degree	Bachelor of Health Care
Degree Programme	Degree programme in Nursing
Instructor	Kirsi Tallman, Principal Lecturer
<p>Open heart surgery patients often experience severe pain caused by tissue damage, rib retraction, sternotomy and drain tubes. Untreated pain after surgery can develop into chronic pain and prolong hospital stays. Pain assessment is the first step in effective pain management. The purpose of this study is to describe pain assessment tools among patients undergoing open heart surgery. The aim is that this gathered information can be used by nurses and other healthcare workers in pain assessment among patients undergoing open heart surgeries.</p> <p>This study is a descriptive literature review, articles were selected from CINAHL and MEDLINE databases. A total of 8 articles were selected and analyzed using descriptive analysis method to identify eight pain assessment tools used in postoperative open heart surgery patients.</p> <p>For critically ill patients who cannot communicate verbally, the use of the Critical Pain Observation Tool (CPOT), Behavioral Pain Scale (BPS), Non-Verbal Pain Scale (NVPS) and Face, Legs, Activity, Cry, Consolability (FLACC) were examined. Among these tools, the CPOT was found to be the most valid and reliable, with a specificity of 86% and sensitivity of 78%. For conscious patients who can communicate verbally, use of the Verbal rating scale (VRS), Red Wedge Scale (RWS), Visual Analogue Scale (VAS), Face Pain Scale (FPS) were examined. Among these tools, VRS was found to be the most feasible tool in pain assessment.</p> <p>Based on the results, the implantation of the CPOT in clinical practice for unconscious patients who cannot report their pain, and the VRS for conscious patients who can report their pain is recommended, however further studies are needed to translate the CPOT to languages other than French or English and validate the translated versions validity and reliability. Additionally, validation of these pain assessment tools in other patient groups is necessary.</p>	
Key Words	Open heart surgery, postoperative pain assessment, pain assessment tools

Tekijä	Hadi Ali
Otsikko	Postoperatiivinen kivun arviointi potilaille joille tehdään avosydänleikkaus
Sivumäärä	22 sivua + 1 liitettä
Aika	20.03.2023
Tutkinto	Sairaanhoitaja AMK
Tutkinto-ohjelma	Sairaanhoitotyö
Ohjaajat	Yliopettaja Kirsi Talman
<p>Avosydänleikkauspotilaat kokevat usein voimakasta kipua, joka johtuu kudonvauriosta, kylkiluiden sisäänvetämisestä, sterotomiasta ja dreeni-putkista. Hoitamaton kipu leikkauksen jälkeen voi kehittyä krooniseksi kivuksi ja pidentää sairaalassaoloa. Kivun arviointi on ensimmäinen askel tehokkaassa kivunhoidossa. Tämän tutkimuksen tarkoituksena on kuvata kivun arviointityökaluja avosydänleikkauspotilailla. Tavoitteena on, että sairaanhoitajat ja muut terveydenhuollon työntekijät voivat käyttää kerättyä tietoa kivun arvioinnissa avosydänleikkauspotilaiden hoidossa.</p> <p>Tämä tutkimus on kuvaava kirjallisuuskatsaus, jonka artikkelit on valittu CINAHL- ja MEDLINE-tietokannoista. Yhteensä 8 artikkelia valittiin ja analysoitiin kuvailevalla analyysimenetelmällä, jotta löydettiin kahdeksan kivun arviointityökalua, joita käytetään leikkauksen jälkeisissä avosydänleikkauspotilaissa.</p> <p>Kriittisesti sairaille potilaille, jotka eivät pysty kommunikoimaan verbaalisesti, Critical Pain Observation Tool (CPOT), Behavioral Pain Scale (BPS), Non-verbal Pain Scale (NVPS) ja Face, Legs, Activity, Cry, Consolability (FLACC):n käyttö on tutkittu. Näistä työkaluista CPOT todettiin pätevimmäksi ja luotettavimmaksi, jonka spesifisyys oli 86 % ja herkkyys 78 %. Tajuissa oleville potilaille, jotka voivat kommunikoida suullisesti, Verbal Pain Scale (VRS), Red Wedge Scale (RWS), Visual Analogue Scale (VAS) ja Facial Pain Scale (FPS) käyttö on tutkittu. Näistä työkaluista VRS todettiin toteuttamiskelpoisimmaksi työkaluksi kivun arvioinnissa.</p> <p>Tulosten perusteella suositellaan CPOT käytettäväksi kliinisessä käytännössä tajuttomille potilaille, jotka eivät voi ilmoittaa kipuaan, ja VRS tajuissaan oleville potilaille, jotka voivat ilmoittaa kipuaan. Lisätutkimuksia tarvitaan kuitenkin CPOT:n kääntämiseksi muille kielille kuin ranskaksi tai englanniksi ja vahvista käännettyjen versioiden kelpoisuus ja luotettavuus. Lisäksi näiden kivunarviointityökalujen validointi muissa potilasryhmissä on tarpeen.</p>	
Avainsanat	Avosydänleikkaus, postoperatiivinen kivun arviointi, kivun arviointi työkalut

## Contents

1	Introduction	1
2	Background	2
2.1	Open heart surgery	2
2.2	Definition of pain	3
2.3	Pain assessment among post open heart surgery patients	3
3	Purpose, aim and study questions	5
4	Methodology	6
4.1	Design	6
4.2	Data search/selection	6
4.3	Data analysis	10
5	Results	10
5.1	Pain assessment tools used to assess pain of conscious and unconscious post open heart surgery patients	10
5.2	Validity, reliability and feasibility of the tools used in pain assessment among post open heart surgery patients	12
6	Discussion	15
6.1	Discussion of the results	16
6.2	Ethics and Validity	17
6.3	Recommendations for future studies	18
7	conclusions	18
	References	19
	Appendices	
	Appendix 1. Table of selected Articles	

## 1 Introduction

According to the world health organization (WHO), several cardiovascular diseases are the most common cause of death globally. In 2019, 17.9 million individuals passed away due to cardiovascular problems (WHO 2021). Open heart surgeries are essential procedures to prevent mortality and improve the quality of the life of patients. The most common types of heart surgeries are coronary artery bypass grafts, heart valve surgeries, thoracic aorta repairs, and surgeries to correct congenital heart defects. (Terveyskylä: Tietoa sydänleikkauksista.) In open heart surgery, the most common incision used is median sternotomy, which requires splitting the sternum in half with a saw, to gain access to the heart and perform the required surgery. Therefore, the major causes of pain in open heart surgeries are rib retraction, sternotomy, and drain tubes. (Shields 2009:397.)

Even after major advances in postoperative pain management methods, patients undergoing surgeries suffer from pain (Nachyande 2018:363). Pain assessment is an important part of the pain management process. Untreated pain after surgery can develop into chronic pain and prolong hospital stays (Aktas & Karabulut 2017:343). Patients who are critically ill, sedated, and mechanically ventilated cannot report their pain, so it is a challenge for healthcare workers to assess the pain in this sample of patients (Marmo & Fowler 2009:134).

Previous studies examined the validation and reliability of different pain assessment tools used for postcardiac surgery patients. In critically ill post-operative open heart surgery patients, numerous studies indicated the validity and reliability of CPOT (critical pain observation tool). (Linde 2013:492.) There is an association between pain and physiological changes such as tachypnea and increased arterial pressure, so vital signs assessment could be useful in pain assessment (Vieira de Andrade & Barbosa and Barichello 2010:228).

The purpose of this study is to describe pain assessment tools among patients undergoing open heart surgery.

## 2 Background

Patients after open heart surgery are subjected to severe pain caused by damage to the tissues or organs during surgery. Untreated acute pain after surgery can develop to chronic pain, it is an unwanted adverse effect of open-heart surgery, and it can lead to a lower quality of life and prolonged pain. (Zubrzycki et al. 2018:1601–1606.)

Open heart surgeries usually last between 5 to 6 hours, after that patients are transferred to intensive care units and extubated within 6 hours (Terveyskylä 2020: Hoito sairaalassa sydänleikkauksen jälkeen). During this time, patients are unconscious and unable to self-report pain, so they are at higher risk of untreated pain (Marmo & Fowler 2009:134). Even with patients able to report their pain verbally, the pain assessment tool must be valid and reliable (Zubrzycki et al. 2018:1600).

### 2.1 Open heart surgery

Open heart surgery is any type of surgery that requires exposing the heart to restore its normal functions (NHLBI 2022: What is heart surgery). The goal of open heart surgery is to improve the quality of life. Open heart surgeries are performed for many reasons, the most common open heart surgeries are done to replace blocked coronary arteries, this surgery is performed by replacing coronary arteries with arteries taken from the legs or hands, also surgeries that replace or repair heart valves that leak, or do not open well are done on the aortic and mitral valves. Sometimes two surgeries are performed in one, such as a valve replacement and coronary artery bypass surgery. (Terveyskylä: Tietoa sydänleikkauksista.)

Before heart surgery, all risk factors such as high age, heart and lung conditions, and other diseases like cancer or kidney failure are taken into consideration to ensure that patients undergoing such a major operation will be able to survive. Tests like coronary angiography, echocardiography, and computer tomography of the heart are usually taken before surgery. (Terveyskylä: Tietoa sydänleikkauksista.)

Open heart surgery usually takes between 5 and 6 hours, after which patients are transferred to intensive care units, where they stay for at least one day. Patients are usually extubated within six hours after surgery, after ensuring that their condition is stable, they are transferred to a heart surgery ward, where they stay for around one week. It can take

up to three months to recover well after surgery. (Terveyskylä 2020: Hoito sairaalassa sydänleikkauksen jälkeen.)

## 2.2 Definition of Pain

The International Association for the Study of Pain (IASP) stated that "Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage ". Pain can be acute or chronic, chronic pain is a continuous pain, and this pain will continue despite the healing or treatment of the illness that caused it. (IASP 2021.) Acute pain develops rapidly, is initially severe or powerful, and there is an underlying behind it, it could be surgery, trauma, or a painful procedure. Acute pain will not last long, it will disappear as soon as the underlying cause behind it disappears. (IASP 2021.)

Postoperative pain in open heart surgery patients is a pain that occurs after surgery, it is an acute pain, it occurs because of tissue or nerve damage, drain tubes, and the presence of a surgical wound. At the site of the trauma, neurogenic inflammation is developed due to tissue damage. Studies have shown that pain is proportional to the length of the surgery and the use of cardiopulmonary bypass can trigger more pain after surgery. (Zubrzycki et al. 2018:1602.)

Pain is a subjective experience and a complex perceptual phenomenon, so it is difficult to assess pain unless patients talk about their experiences. People experience pain differently because it is an individual experience. The ones experiencing pain are the best experts in their pain and only they can define the intensity, it is important to trust patients and believe them because they are the only ones that know if they are in pain or not. (Turk & Meliack 2011:6.) There are tools designed to measure pain in patients who are unable to communicate verbally, mechanically ventilated, sedated or unconscious patients that are not able to describe their pain (Salanterä, Heikkilä, Kauppila, Murtola & Siltanen, 2013:6-8).

## 2.3 Pain assessment among post open heart surgery patients

Pain assessment is a complex observation of pain, there is no tool or method that can tell healthcare professional how much the patients is experience of pain, instead patients themselves express their pain, in conscious patients it's possible to express their pain verbally, and unconscious patients still have the ability to express their pain from their

behaviors, such as facial expression. Pain assessment is an essential part of the pain management process for several reasons, such as to make a differential diagnosis or to evaluate the response to treatment, along with the need to continue or modify a treatment program, and to monitor the progression after pain treatment. (Turk & Meliack 2011:6-8.)

Pain assessment is a challenging task for healthcare workers, patients' description of pain is considered the best pain assessment method. Patients are asked to quantify their pain according to a scale from 1 to 10, or mild, moderate, and severe. However, patients are different, and nurses should not depend only on what patients are saying, instead it is important to recognize the reasons for pain, sometimes patients overestimate or underestimate their pain level, and pain intensity will vary between times and depend on what the patient is doing. (Turk & Meliack 2011:6-8.) Patient's vital signs, such as breathing, movements, consciousness, and gestures should be monitored to assess the pain. However, monitoring vital functions alone is not enough to measure pain, in addition, more precise methods are needed. (Arbour & Gelinias 2010:87-89.)

During surgery a nerve could be damaged, and in that case, it will cause acute pain. It is important to recognize and treat acute pain, studies showed that untreated acute pain after surgery can develop into chronic pain in around 10 to 50 percent of the patients (Salanterä, Heikkilä, Kauppila, Murtola & Siltanen 2013:3-5.) Pain should be evaluated and assessed postoperatively, because it guides health care personnel towards the patient's individual and medical treatment. When evaluating pain, the patient's fear, depression, anxiety, gender, previous pain experiences, and the nature of the procedure should all be considered. All these factors affect the patient's pain experience and subsequent evaluation of the operation. (Salanterä, Heikkilä, Kauppila, Murtola & Siltanen 2013:6-11.)

Pain assessment tools are tools designed to measure pain. There are different pain assessment tools to measure pain in conscious and unconscious patients. Studies are limited on the pain assessment tools for unconscious patients. Behavioral Pain Scale (BPS) and Critical-Care Pain Observation Tool (CPOT) (Figure 1), are pain assessment tools recommended by the American Society for Pain Management and Nursing (ASPMN) for pain assessment of unconscious patients. (Fowler & Marmo 2010.)

Figure 1: Critical pain observation tool (Gelinás et al. 2006)

Indicator	Description	Score	
Facial expression	No muscular tension observed	Relaxed, neutral	0
	Presence of frowning, brow lowering, orbit tightening, and levator contraction	Tense	1
	All of the above facial movements plus eyelid tightly closed	Grimacing	2
Body movements	Does not move at all (does not necessarily mean absence of pain)	Absence of movements	0
	Slow, cautious movements, touching or rubbing the pain site, seeking attention through movements	Protection	1
	Pulling tube, attempting to sit up, moving limbs/ thrashing, not following commands, striking at staff, trying to climb out of bed	Restlessness	2
Muscle tension Evaluation by passive flexion and extension of upper extremities	No resistance to passive movements	Relaxed	0
	Resistance to passive movements	Tense, rigid	1
	Strong resistance to passive movements, inability to complete them	Very tense or rigid	2
Compliance with the ventilator (intubated patients)	Alarms not activated, easy ventilation	Tolerating ventilator or movement	0
	Alarms stop spontaneously	Coughing but tolerating	1
	Asynchrony: blocking ventilation, alarms frequently activated	Fighting ventilator	2
OR			
Vocalization (extubated patients)	Talking in normal tone or no sound	Talking in normal tone or no sound	0
	Sighing, moaning	Sighing, moaning	1
	Crying out, sobbing	Crying out, sobbing	2
Total, range			0-8

Other common pain assessment tools for conscious patients are Visual Analogue Scale (VAS), Numerical Rating Scale (NRS), Verbal Rating Scale (VRS), and Facial Pain Scale (FPS). The patient's selection of a pain tool is documented in the patient's records, and the same pain tool is used throughout the treatment period. (Salanterä, Heikkilä, Kaupila, Murtola & Siltanen 2013: 12.)

### 3 Purpose, aim and study questions

The purpose of this study is to describe pain assessment tools among patients undergoing open heart surgery.

The aim is that this gathered information can be used by nurses and other healthcare workers in pain assessment among patients undergoing open heart surgeries.

Research questions:

1. What pain assessment tools have been used in assessing the pain of conscious and unconscious patients after open heart surgery?

2. What pain assessment tools have been found valid, reliable, and feasible in assessing pain in conscious and unconscious patients after open heart surgery?

## 4 Methodology

### 4.1 Design

This study method is a descriptive literature review. A literature review is a review of existing literature around a particular topic by searching and analyzing previous studies and theories. Its goal is to search for an answer to a particular research question. It is objective, the writer does not bring his own point of view to the text. This study is a descriptive (aka narrative) literature review, in this type the writer analyses and draws a conclusion about a particular literature. (Cronin, Ryan & Coughlan 2007:39-41.)

There are four phases in a literature review. The first phase starts with selecting a topic and formulating a research question. The second phase is searching for literature from databases and selecting the appropriate literature that answers the research question. The third phase is to analyze and summarize the literature. The last stage is writing the review. (Cronin, Ryan & Coughlan 2007:39-41.)

### 4.2 Data search and selection

Facet analysis was used to identify relevant search terms (Table 1). This type of analysis is the most perspicuous in knowledge organization (Hjørland 2013: 545). PEO format was used to identify key concepts and formulate the research question. PEO is mainly used in qualitative research, P is an abbreviation for population and their problems, E for exposure to an illness or a condition, and O stands for outcome or themes (University of Suffolk 2023).

Table1. Facet analysis

<b>Population:</b> <b>Patients undergoing open heart surgeries</b>	<b>Exposure:</b> <b>Assessment methods</b>	<b>Outcome:</b> <b>Pain</b>
open heart surger*	assessment method*	pain
OR	OR	OR
open-heart surger*	assessment tool	suffering

OR	OR	OR
cardiothoracic surger*	assessment scale	discomfort
OR	OR	
median sternotomy	evaluation	
OR		
cardiac surgery		
OR		
heart surgery		

In this study, searching for literature was done using two electronic databases (CINAHL, MEDLINE). CINAHL was chosen because it is one of the top databases in the healthcare field that includes a collection of 3,223 peer-reviewed journals (EBSCO 2022). MEDLINE was selected because it is a database of healthcare and biomedical information; it provides access to more than 5600 journals in around 40 different languages (Wolters Kluwer Health 2022).

The main search terms based on facet analysis were combined using Boolean operators (AND, OR) that combine or exclude words, to form a search phrase that was used in both CINAHL and MEDLINE (Table 2). Database searches were limited in publication time after 2007 and the presence of abstract. All hits were screened by reading the title, after that reading the abstract and then the full text.

Table 2. Data Search Results

<b>Data-base</b>	<b>Search Terms</b>	<b>Limiters</b>	<b>Numbers of hits</b>	<b>Selected based on the title</b>	<b>Selected based on abstract</b>	<b>Selected based on full text</b>
CINAHL	("Open heart surger* "OR "open-heart surger* "OR cardiothoracic surger* OR "median sternotomy*" OR "cardiac surgery" OR "heart surgery") And (assessment or evaluation or measurement or scale or tool*) And (pain or discomfort or suffering).	published after 2007 Abstract	n=495	n=32	n=8	n=4
Medline	("Open heart surger* "OR "open-heart surger* "OR cardiothoracic surger* OR "median	Abstract published after 2007	n=530	n=16	n=7	n=4

	sternotomy** OR "cardiac surgery" OR "heart surgery") And (assessment or evaluation or measurement or scale or tool*) And (pain or discomfort or suffering).					
			Total n=1020	Total n=48	Total n=15	Total n=8

Inclusion and exclusion criteria were set for the review to identify which kind of studies can be included in this review (Table 3). The selection criteria were related to population, time of publication, language, and relevance to the topic. The study must be relevant to the topic, and the timeframe should be up to date to get the newest possible information about the topic, languages unfamiliar languages to the writer were excluded.

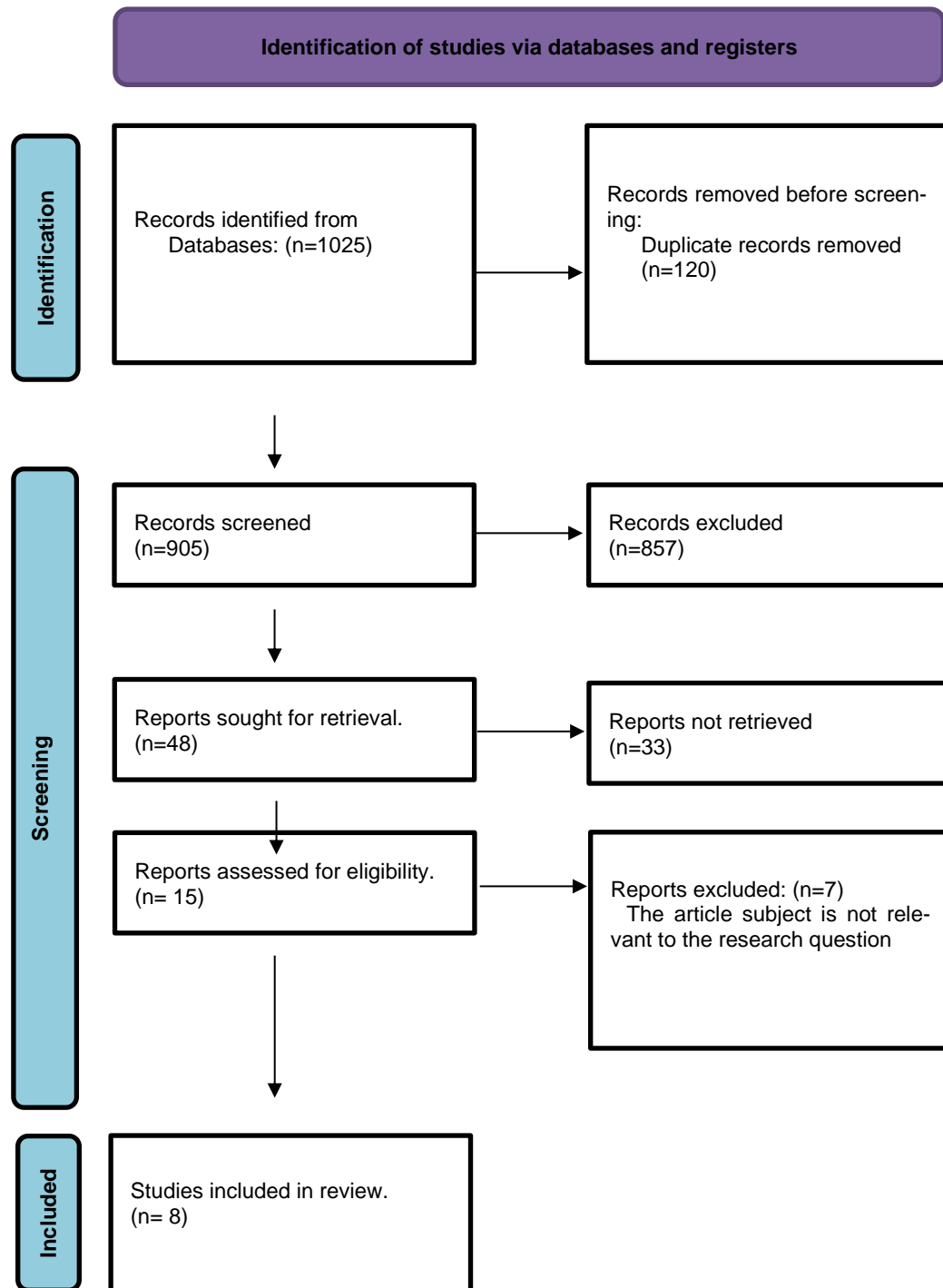
Table 3. Inclusion and exclusion criteria

Inclusion criteria	Exclusion Criteria
Peer-reviewed articles	Other than peer-reviewed articles
Published between 2007–2022	Published before 2007
English and Finnish language	Non-English and non-Finnish language
Studies related to the topic of pain assessment tools in conscious and unconscious adult patients after open heart surgery	Studies not related to the topic, for example studies talking about pain management or in non-adult population

The selected articles were inspected for their quality using the JBI Critical Appraisal Skills Programme (CASP) by choosing 4 questions from the Cohort studies checklist about the validity and reliability of the measured exposure, if statistical analysis was appropriate, or if the exposures measured similarly to assign people to both exposed and unexposed groups, and if the participants were free of the outcome at the start of the study (Appendix 1). To make sure that the articles are published by peer-reviewed journals, Jufo (julkaisufoormi) is used. JUFO is a Finnish journal rater, it has four classifications, 0 means that the journal doesn't meet the quality criteria, 1 is basic, 2 is leading and 3 is top (Publication Forum 2022).

Prisma flow diagram below demonstrates the data selection process for this review (Figure 1). The total number of records from both databases was 1020 and finally, after reading abstracts and full texts, eight studies were included for the review.

Figure 1: Prisma flow diagram



### 4.3 Data analysis

In this review, descriptive analysis method was used to describe and summarize the quantitative data/results from the selected studies, and to draw conclusions to answer the research questions (Botti & Endacott 2005:191).

First, a table of the selected articles was established. This table included the aim, methodology, participants, and main results of each article (Appendix 1). Two more tables were created to present the results of the analysis clearly and concisely. The tables were formed to answer the research questions. The first table presented all the described pain assessment tools in the selected articles, their purpose, scale, background, population, and mechanism of pain rating for each tool (Table 4). The second table presented features of the pain assessment tools such as validity, reliability, specificity/sensitivity, and feasibility (Table 5). The goal of these tables was to include all the relevant information about the tools from the selected articles and present it in an organized and summarized way (Botti & Endacott 2005:191).

## 5 Results

The purpose of this study was to describe pain assessment tools among patients undergoing open heart surgery. A total of eight studies were included in this study (Gelinias et al. 2009, Pesonen et al. 2007, Marmo and Fowler 2010, Kotfis et al. 2013, Keane 2013, Linde 2013, Boitor et al. 2016, Rijkenberg et al. 2017). One study was done in Finland, three in the USA, three in Canada, one in Poland and one in the Netherlands. Studies were conducted between 2008 to 2017. All patients that participated in these studies were postoperative open heart surgery patients. Seven studies out of eight described pain assessment tools used in critically ill unconscious patients, while one study described pain assessment tools used in conscious patients who can report their pain verbally.

### 5.1 Pain assessment tools used to assess pain of conscious and unconscious post open heart surgery patients

The studies selected for this review examined eight tools used in pain assessment in postoperative open heart surgery patients (Table 4). The tools are Verbal Rating Scale (VRS), Red Wedge Scale (RWS), Facial Pain Scale (FPS), Visual Analogue Scale

(VAS), Critical Pain Observation Tool (CPOT), Behavioral Pain Scale (BPS), Non-verbal pain scale (NVPS), and Face, Legs, Activity, Cry, Consolability Scale (FLACC).

Pain assessment tools used in critically ill patients who cannot communicate verbally, sedated and mechanically ventilated are: Critical Pain Observation Tool (CPOT), Behavioral Pain Scale (BPS), Non-verbal pain scale (NVPS), and Face, Legs, Activity, Cry, Consolability Scale (FLACC). These tools are all pain assessment tools that monitor the behaviors of the patients, such as facial expression, body movements and vital signs. The tools consist of categories, which the pain rater uses to calculate a score, the minimum score indicates no pain, and the maximum score indicates the highest possible pain. (Table 4.)

Pain assessment tools used in the assessment of pain in conscious patients who can communicate verbally are Verbal Rating Scale (VRS), Red Wedge Scale (RWS), Facial Pain Scale (FPS), Visual Analogue Scale (VAS). These pain assessment tools depend on patients rating of pain. Patients are asked to rate their pain based on a scale for example in Verbal Rating Scale (VRS) patients are asked to report their level of pain and choose a number that express their pain. (Table 4.)

Table 4: Pain assessment tools used in assessing the pain of conscious and unconscious patients after open heart surgery.

<b>Pain assessment tool</b>	<b>Purpose of the instrument</b>	<b>Background</b>	<b>Scale</b>	<b>Mechanism of pain rating</b>
Critical pain observation tool (CPOT)	Assessment of pain in Critically ill patients who are unable to communicate verbally	This pain assessment tool is developed in Canada by Celine Gelinis and her team	4 behavioral indicators, facial expression, Body movements, Muscle tension and compliance	Each one of the 4 category is scored on 0-2 scale which gives a total score of 0-8
Face, Legs, Activity, Cry, Consolability scale (FLACC)		It was initially developed to detect post-operative pain in children under 7	5 categories of face, legs, activity, crying, and consolability	Each one of the 5 category is scored on 0-2 scale which gives a total score of 0-10
Nonverbal pain scale (NVPS)		This pain assessment tool was developed from FLACC scale by eliminating the leg, cry and consolability categories, and adding vital signs to the scale	5 categories of face, movement, guarding, physiology and Respiratory	Each one of the 5 category is scored on 0-2 scale which gives a total score of 0-10

Behavioral pain scale (BPS)		It was developed to assess pain in general ICU unit's patients	3 categories: facial expression, movements of the upper limbs, and compliance with ventilation	Each one of the 3 categories is scored from 1 (no response) to 4 (full response) which gives a total score of 3-12 points
Verbal rating scale (VRS)	Assessment of pain in patients who can communicate verbally	It is the simplest verbal pain assessment tool	5 options that patients can choose, 0 means no pain at all, 1 mild pain, 2 moderate pain, 3 severe pain and 4 unbearable pains.	Patients are asked to report their level of pain and choose a number
Red wedge scale (RWS)		It was developed to assess the pain in surgical patients after surgery in patients recovering from general anesthesia	50 cm red-colored horizontal scale	Patients show on the scale their level of pain
Visual analogue scale (VAS)		It is one of the most common scales used in pain assessment of conscious patients who can communicate verbally	10 cm line with 2 endpoints, 0 means no pain and 10 the most possible pain	Patients show on the scale their level of pain
Facial pain scale (FPS)		It was developed for pain assessment in children older than 3 years old, later it was upgraded and used in adult patients	A Series of 7 faces, the smiley face indicates that there is no pain at all and the face with tears indicates the most possible pain	Patients choose a face that describes their level of pain

## 5.2 Validity, reliability and feasibility of the pain assessment used to assess pain of conscious and unconscious post open heart surgery patients

In critically ill patients who are unable to communicate, Critical Pain Observation Tool (CPOT) was the most described by the studies, five out of eight studies included in this review described the validity and reliability of CPOT, and one study described the sensitivity/specificity of CPOT, all the articles affirmed the validity and reliability of CPOT, and it showed a specificity of 86% and sensitivity of 78%. CPOT has been used as a base to identify the validity of other pain assessment tools (Rijkenberg et al. 2017). The validity has been confirmed in different ways, such as calculating CPOT scores during

nociceptive procedures, and calculating the correlation between patient's self-report of pain and CPOT score. The reliability has been confirmed by comparing the result of different nurse raters, calculating Cronbach's alpha, and Interrater Cohen's weighted kappa. Behavioral Pain Scale (BPS) has been described in two studies out of eight, both studies confirmed its validity and reliability. Non-Verbal Pain Scale (NVPS) and Face, Legs, Activity, Cry, Consolability Scale (FLACC) have been described in one study and this study confirms their reliability. (Table 5.)

Among tools used in pain assessment of conscious patients who can communicate verbally, one study out of eight examined the feasibility of Verbal Rating Scale (VRS), Facial pain Scale (FPS), Red Wedge Scale (RWS) and Visual Analogue Scale (VAS) in pain assessment (Pesonen et al. 2007). The results showed that VRS was the most feasible tool in pain assessment, the feasibility was measured by assessing the pain using the above-mentioned tools on patients, then calculating the success rates of these tools based on the patient's ability to express their pain on these tools, VRS showed a success rate of 86 % in pain assessment at day one after surgery and RWS 78%, the other pain assessment tools scored less 65% which makes them not suitable in the pain assessment. (Table 5.)

Table 5: Validity, Reliability, Sensitivity/Specificity, and Feasibility of the pain assessment tools

Pain assessment tool	Validity	Reliability	Sensitivity/Specificity	Feasibility
CPOT (critical pain observation tool)	<p>-CPOT score increased during nociceptive procedures (Keane 2013)</p> <p>-CPOT score increased during Turning which is a painful procedure (increased, +3.04; 95% CI, 2.11 to 3.98) while being stable during dressing which is a non-painful procedure (increased, +0.25; 95% CI, -0.07 to 0.57) (Linde 2013).</p> <p>-CPOT scores increased during nociceptive procedures (Mediastinal Tube Removal) mean SD, 2.74 compared to non-painful procedures mean SD, 0.50 (Boitor et al. 2016).</p> <p>-A correlation between CPOT scores and patients</p>	<p>-Total agreement between both nurses on pain assessment using CPOT (critical pain observation tool) was 80 per cent (60 out of 75 observations) for suctioning procedure and 85 percent (64/75) for turning procedure (Marmo &amp; fawler 2010)</p> <p>-Interclass correlation (0.578-0.862) between rater 1 and rater 2(Boitor et al. 2016).</p> <p>-Cronbach's alpha 0.65 and 0.58 for nurse 1 and 2 respectively (Rijkenberg et al. 2017)</p> <p>-Interrater reliability kappa coefficients 0.34-1 (fair to perfect) (Keane 2013)</p>	-Sensitivity 86% and Specificity 78%.	Not reported

	self-report ( $r = 0.419$ , $P < .01$ ) (Boitor et al. 2016) -CPOT scores increased by 2 points during nociceptive procedures (Rijkenberg et al. 2017)	-Interrater Cohen's weighted kappa was high 95% CI, 0.79-0.94 (Linde 2013)		
BPS (behavioral pain scale)	-BPS scores increased by 2 points during nociceptive procedures (Rijkenberg et al. 2017). -BPS scores were high during nociceptive procedures in both rating nurses and patients self-report (Koftis et.al 2013).	-Intraclass correlation coefficients $>0.86$ for rater A and rater B (Koftis et al. 2013). - BPS scale was high in both rating nurses (mean SD $4.35 \pm 0.90$ ) by rater A and rater B mean SD $4.38 \pm 0.94$ ) (Koftis et.al 2013). - Cronbach's alpha 0.62 and 0.59 for nurse 1 and 2 respectively (Rijkenberg et al. 2017)	Not reported	Not reported
NVPS (Nonverbal pain scale)	Not reported	-Identical Cronbach alpha coefficients of 0.89 between NVPS and CPOT - Total agreement between nurses on NVPS (non-verbal pain scale) was 78% (58 out of 75) for suctioning procedure and 79% (59 out of 75) for the turning procedure. (Marmo & Fawler 2010)	Not reported	Not reported
FLACC (Face, Legs, Activity, Cry, Consolability scale)	Not reported	-Total agreement between nurses was 78% (58 out of 75) for suctioning procedure and 84% (63 out of 75) for the turning procedure (Marmo & Fawler 2010)	Not reported	Not reported
VRS (verbal pain scale)	Not reported	Not reported	Not reported	- Success rates of these tools based on the patient's ability to express their pain was 86%

VAS (Visual analogue scale)	Not reported	Not reported	Not reported	- Success rates of these tools based on the patient's ability to express their pain was 62%
RWS (red wedge scale)	Not reported	Not reported	Not reported	- Success rates of these tools based on the patient's ability to express their pain was 78%
FPS (Facial pain scale)	Not reported	Not reported	Not reported	- Success rates of these tools based on the patient's ability to express their pain was 60%

## 6 Discussion

### 6.1 Main results

The purpose of this study was to describe the methods of pain assessment among patients undergoing open heart surgery. A total of eight studies selected for this review examined eight tools used in pain assessment in postoperative open heart surgery patients. The tools are Verbal Rating Scale (VRS), Red Wedge Scale (RWS), Facial Pain Scale (FPS), Visual Analogue Scale (VAS), Critical Pain Observation Tool (CPOT), Behavioral Pain Scale (BPS), Non-verbal pain scale (NVPS), and Face, Legs, Activity, Cry, Consolability Scale (FLACC).

According to the results of this review, Critical Pain Observation Tool (CPOT) was found as the most valid and reliable tool to assess pain in unconscious postoperative open heart surgery patients. A total of five out of eight studies selected for this review, examined the validity and reliability, and one study out of eight examined the specificity and sensitivity of Critical Pain Observation Tool (CPOT), it was the most researched tool among all the tools included for this review. CPOT validity and reliability was assessed by using different methods. As a limitation, the original version of CPOT is available only in French or English. Some studies examined the validity and reliability of the translated version of CPOT such as German version of CPOT, and the results confirmed its validity and reliability (Kieswetter et al. 2019:841). One of the selected studies (Rijkenberg et al. 2017), showed an insufficient value of Cronbach's alpha to indicate the reliability of CPOT, however the reliability of CPOT have been affirmed by other studies included for this review. Cronbach's alpha is a method to measure the reliability of the tools, it should be more than 0.7 and above, to consider the tool as a reliable tool (Houser 2008:297).

Other assessment tools have some limitations, such as Non-Verbal Pain Scale (NVPS) which include vital signs assessment, vital signs assessment is not valid in pain assessment among postcardiac surgery patients because of hemodynamic changes (Arbour & Gelinas 2010:90). There was no correlation between vital signs and patients self-report of pain (Boitor & Fiola & Gelinas 2016:431). Behavioral Pain Scale (BPS) is valid and reliable, but it has only three categories to assess pain, unlike CPOT which includes four categories and can assess pain in depth. All pain scales included in this review are not able to detect pain in patients with Neuromuscular disorders or received neuromuscular blocking agents (Linde 2013:496).

Among conscious patients who can communicate verbally, the gold standard in pain assessments is a patient expression of pain, in case patients are awake and can communicate verbally, using a simple pain assessment method is the best choice (Turk & Melizack 2011:6-8). Verbal Rating Scale (VRS) is a simple and straightforward tool, and it showed the highest success rate in detecting pain (Pesonen, Suojäranta-Ylinen, Tarkkila & Rosenberg 2007:267).

There were no previous literature reviews about pain assessment among post open heart surgery patients, so it is not possible to compare the result with other studies. Despite having wide search terms and getting a huge number of hits, many studies were not related to the research questions. Pain assessment is just one part of the pain management process thus it is a narrow subject, and it was not easy to find literature about this topic. The result of this review confirms what is known about the validity and

reliability of Critical Pain Observation Tool (CPOT) in pain assessment among patients who cannot communicate verbally.

## 6.2 Ethics and validity

Ethics are defined as “a set of moral principles” (Merriam-Webster 2022). This review followed the guidelines of the Finnish National Board on Research Integrity TENK (TENK 2019). In this review, there was no direct human participant, all the data were collected from other studies. The guidelines of (Arene) were adhered (Arene 2020), the author got familiarized with the guidelines before starting the thesis process. The text written is scientific, and the information presented is in a logical form. All phases of this study were done with accuracy and the results are presented with honesty.

The search term was wide, and it gave a huge number of hits, this adds to validity of this review because it included all the possible literature available on this topic. Databases used in this review are one of the top databases in healthcare field, and it includes a wide collection of peer-reviewed journals. These databases are recommended by Metropolia University of Applied Sciences

Literature review results depend totally on the selected articles, so it is important to select high-quality articles. To make sure that articles are published in peer-reviewed journals, julkaisufoorumi, which is a system to rate the journals, was used. The selected articles quality was inspected using the JBIs Critical Appraisal skills programme (CASP).

As a limitation, one author conducted this review, so it was not possible to compare the data selection, analysis and reporting of the results between two authors, this is a factor that may affect reliability negatively. However, data selection process was done carefully, the author double checked the data selection process, the results from the selected articles was tabulated and these tables were included in the thesis for accurate and transparent reporting of the results.

To avoid plagiarism, the Turnitin programme was used. Turnitin is a widely used programme to detect plagiarism. In the reporting phase, the results were reported as they are in the original articles without including any personal opinion.

### 6.3 Recommendations for future studies

This review concluded that CPOT (critical pain observation tool) is the most valid and reliable tool, as a limitation it is only available in French and English. Future studies may translate CPOT to any other language which is not translated yet. Also, to examine the validity and the reliability of the translated version of CPOT (critical pain observation tool), to help healthcare professionals speaking the translated language, and adapt the tool culturally. In this review the focus was on a specific patient group, which is post open heart surgery patients, so it is recommended to examine the validity and reliability of the assessment tools in other patient groups. CPOT (critical pain observation tool) is recommended to be implanted in the clinical practice in pain assessment of unconscious patients who are not able to report their pain, and VRS (verbal rating scale) in conscious patients who are able to report their pain.

## 7 Conclusion

This review found a total of eight assessment tools used in pain assessment of conscious and unconscious after open heart surgery, four tools for each group. Among unconscious postoperative open heart surgery patients CPOT (critical pain observation tool) was the most reliable and valid. Among conscious postoperative open heart surgery patients only verbal rating scale and red wedge scale showed feasibility in the pain assessment. Further studies are needed to translate the CPOT to languages other than French or English and validate the translated versions validity and reliability. Additionally, validation of these pain assessment tools in other patient groups is necessary.

## References

- Aktaş, Y.Y. & Karabulut, N. 2017. A Turkish Version of the Critical-Care Pain Observation Tool: Reliability and Validity Assessment. *Journal of Perianesthesia Nursing* 32 (4). 341–351.
- Arbour, C. & Gelinas, C. 2010. Are vital signs valid indicators for the assessment of pain in postoperative cardiac surgery ICU adults. *Intensive and critical care nursing* 26 (2). 83–90.
- ARENE. 2019. Ethical recommendation for thesis writing at universities of applied sciences. <[https://www.arene.fi/wp-content/uploads/Raportit/2020/ETHICAL%20RECOMMENDATIONS%20FOR%20THESIS%20WRITING%20AT%20UNIVERSITIES%20OF%20APPLIED%20SCIENCES\\_2020.pdf?t=1578480382](https://www.arene.fi/wp-content/uploads/Raportit/2020/ETHICAL%20RECOMMENDATIONS%20FOR%20THESIS%20WRITING%20AT%20UNIVERSITIES%20OF%20APPLIED%20SCIENCES_2020.pdf?t=1578480382) > Accessed 23.02.2023
- Botti, M. & Endacott, R. 2005. Clinical research 5: Quantitative data collection and analysis. *Intensive and Critical Care Nursing* 21 (3). 187–193
- Boitor, M. & Fiola, L. J. & Gelinas C. 2016. Validation of the Critical-Care Pain Observation Tool and Vital Signs in Relation to the Sensory and Affective Components of Pain During Mediastinal Tube Removal in Postoperative Cardiac Surgery Intensive Care Unit Adults. *Journal of Cardiovascular Nursing* 31 (5). 426–432.
- Cronin, P. & Ryan, F. & Coughlan, M. 2008. Undertaking a literature review: A step-by-step approach. *British Journal of Nursing* 17 (1). 38–42.
- EBSCO 2022. CINAHL database <<https://www.ebsco.com/products/research-databases/cinahl-database> >. Accessed 26.12.2022.
- Fowler, S. & Marmo, L. 2010. Pain assessment tool in the critically ill post open heart surgery patient population. *Pain Nursing Management* 11 (3). 134–140.
- Gelinas, C. & Fillion, L. & Puntillo, K. & Viens, C. & Fortier, M. 2006. Validation of the critical-care pain observation tool in adults. *American Journal of Critical Care* 15 (4). 420–427.

Gelinas, C. & Harel, F. & Fillion, L. & Puntillo, K.A. & Johnston C. C. 2009. Sensitivity and Specificity of the Critical-Care Pain Observation Tool for the Detection of Pain in Intubated Adults After Cardiac Surgery. *Journal of Pain and Symptom Management* 37 (1). 59–67.

Hjørland, B. 2012. Facet analysis: The logical approach to knowledge organization, *Information Processing & Management* 49 (2). 545–557.

Houser, J. 2008. Precision, Reliability, and Validity: Essential Elements of Measurement in Nursing Research. *Journal for Specialists in Pediatric Nursing* 13 (4). 297–299.

International association for the study of pain (IASP). 2021. Acute pain <<https://www.iasp-pain.org/resources/topics/acute-pain>>. Accessed 20.01.2023.

Koftis, K. & Marta, S. & Zegan-Baranska, M. & Safranow, K. & Brykczynski, M. & Zukowski, M., Wesley E. 2018. Validation of the behavioral pain scale to assess pain intensity in adult, intubated postcardiac surgery patients. *Medicine Baltimore* 97 (38). 1–9.

Keane, K.M. 2013. Validity and Reliability of the Critical Care Pain Observation Tool: A Replication Study. *Pain Management Nursing* 14 (4). 216–225.

Kiesewetter, I. & Bartels, U. & Bauer, A. & Schneider, G. & Pilge, S. 2019. The German version of the Critical-Care Pain Observation Tool for critically ill adults. *Anaesthesist* 68 (12). 836–842.

Linde, S.M. (2013). Reevaluation of the Critical-Care Pain Observation Tool in Intubated Adults After Cardiac Surgery. *American Journal of Critical Care* 22 (6). 491–497.

Meriam-Webster 2023. Ethics definition. < <https://www.merriam-webster.com/dictionary/ethic> >. Accessed 02.02.2023.

National heart, lung, and blood institute (NHLB).2022. what is heart surgery. <<https://www.nhlbi.nih.gov/health/heart-surgery#:~:text=Heart%20surgery%20is%20done%20to,such%20as%20a%20heart%20attack>> Accessed 10.11.2022

Nachyande, B. & Lam, L. 2018. The efficacy of different modes of analgesia in postoperative pain management and early mobilization in postoperative cardiac surgical patients: A systematic review. *Annals of cardiac anesthesia* 21 (4). 363–370.

Publication Forum 2022. Publication Forum. < <https://julkaisufoorumi.fi/en/publication-forum>>. Accessed 28.12.2022.

Pesonen, A. & Suojaranta-Ylinen, R. & Tarkkila, P. & Rosenberg, P.H. 2007. Applicability of tools to assess pain in elderly patients after cardiac surgery. *Acta Anaesthesiologica Scandinavica* 52 (2). 267–273.

Rijkenberg, S. & Stilma, W. & Bosman, R.J. & Van der Meer, N.J. & Van der Voort, P.H.J. 2017 Pain Measurement in Mechanically Ventilated Patients After Cardiac Surgery: Comparison of the Behavioral Pain Scale (BPS) and the Critical-Care Pain Observation Tool (CPOT). *Journal of cardiothoracic and vascular anesthesia* 31 (4).1227–1234.

Salanterä, S. & Heikkilä, K. & Kauppila, M. & Murtola, M-L. & Siltanen, H. 2013. Aikuispotilaan kirurgisen toimenpiteen jälkeinen lyhytkestoinen kivun hoitotyö – Hoitotyön suositus, 5–16.

Shields, T. & LoCicero, J. & Reed, C. & Feins, R. 2009. General Thoracic Surgery seventh edition. In Blum G. M., Fry A. W. (Eds) Thoracic incision. E book. Philadelphia: Lippincott Williams & Wilkins. 397.

TENK 2019. The ethical principles of research with human participants and ethical review in the human sciences in Finland. <[https://tenk.fi/sites/default/files/2021-01/Ethical\\_review\\_in\\_human\\_sciences\\_2020.pdf](https://tenk.fi/sites/default/files/2021-01/Ethical_review_in_human_sciences_2020.pdf)>. Accessed 18.01.2023.

Terveyskylä 2020. Sydänleikkaukset. Tietoa sydänleikkauksista. The reference in Finnish. In English: Health Village 2020: Heart surgeries. Information about heart surgery. < <https://www.terveyskyla.fi/sydansairaudet/toimenpiteet/sydänleikkaukset/tietoa-sydänleikkauksista>>. Accessed 14.11.2022.

Terveyskylä 2020. Sydänleikkaukset. Hoito sairaalassa sydänleikkauksen jälkeen. The reference in Finnish. In English: Health Village 2020: Heart surgeries.Hospital

treatment after heart surgery. < <https://www.terveyskyla.fi/sydansairaudet/toimenniteet/syd%C3%A4nleikkaukset/hoito-sairaalassa-syd%C3%A4nleikkauksenj%C3%A4lkeen>>. Accessed 14.11.2022.

Turk, D. C., Melizack, R. 2011. Handbook on pain assessment third edition. The Measurement of Pain and the Assessment of People Experiencing Pain. Newyork: Guilford press. 5–8.

University of Suffolk 2023. Advanced Literature Search Guide for Health: STEP 2: Formulate your question. < <https://libguides.uos.ac.uk/AdvancedLiteratureSearchGuide/step2> >. Accessed 11.02.2023.

Vieira de Andrade, E. & Barbosa, H. H. & Barichello E. 2010. Pain assessment in post-operative cardiac surgery. Acta paul. enferm 23 (2). 224–229.

Wolters Kluwer Health 2022. Ovid MEDLINE < <https://www.wolterskluwer.com/en/solutions/ovid/ovid-medline-901> >. Accessed 27.12.2022.

World health organization (WHO). 2021. cardiovascular diseases. <[https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-\(cvds\)](https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds))>. Accessed 04.01.2023.

Zubrzycki, M. & Liebold, A. & Skrabal, C. & Reinelt, H. & Ziegler, M. & Perdas, E. & Zubrzycka, M. 2018. Assessment and pathophysiology of pain in cardiac surgery. Journal Pain Research 11. 1599–1611.

## Appendix 2

2 (2)

Appendix 1: Table of selected articles

<b>Authors, year, country</b>	<b>Aim</b>	<b>Methodology and methods</b>	<b>Participants</b>	<b>Main outcomes</b>	<b>JUFO/CASP</b>
1 Gelinás et al. 2009 Canada	To evaluate the sensitivity and specificity of CPOT (Critical pain observation tool)	Quantitative Repeated measurement design	N=105 post-operative cardiac surgery patients	The specificity and sensitivity of CPOT was 86% and 78% respectively. These numbers were calculated by using patients self-report of pain during painful procedures	JUFO: Journal of Pain and Symptom Management:1 CASP: Question 1: yes Question 2: yes Question 3: yes Question 4: yes
2 Pesonen et al. 2008 Finland	To identify the more feasible in the pain assessment of patients undergoing open heart surgery among the Verbal Rating Scale (VRS), Facial pain Scale (FPS), Red Wedge Scale (RWS) and Visual Analogue Scale (VAS).	Quantitative Repeated measures design	N=160 post-operative cardiac surgery patients	The success rates of these tools based on the patient's ability to express their pain on these tools, VRS showed a success rate of 86 % in pain assessment at day 1 after surgery and RWS 78%, the other pain assessment tools scored less 65% which makes them not suitable in the pain assessment. VRS was the more feasible in pain assessment, after that RWS.	JUFO: Acta anaesthesiologica scandinavica: 1 CASP: Question 1: yes Question 2: yes Question 3: yes Question 4: yes
3 Marmo and Fowler 2010 USA	To examine 3 pain assessment tools (CPOT, NVPS and FLACC) and determine which one is more reliable in pain assessment in critically ill postoperative	Quantitative Repeated-measures design	N=2 nurses did 300 observations about 25 subjects	Both nurses did the observation independently about painful procedures (Turning and suctioning), the total agreement between both nurses on pain assessment using Critical Pain Observation Tool CPOT was 60 observations out of 75 (80%) for the suctioning procedure and 64 observations out of 75 (85%) for turning procedure.	JUFO: Pain Management Nursing 1 CASP: Question 1: yes Question 2: N/A Question 3: yes

Appendix 2

2 (2)

	open heart surgery patients			<p>While using Non-verbal pain scale, both nurses agreed on 58 observations out of 75 (78%) for suctioning procedure and 59 observations out of 75 (79%) for the turning procedure.</p> <p>The total agreement using the Faces, Legs, Activity, Cry, and Consolability scale (FLACC) was 58 observations out of 75 (78%) for suctioning procedure and 63 observations out of 75 (84%) for the turning procedure.</p> <p>Nurse agreements show that these tools are reliable in pain assessment of patients after open-heart surgery.</p>	Question 4: yes
4 Kottis et al. 2013 Poland	To identify if the Behavioral pain scale (BPS) is a valid and reliable tool in pain assessment in post-cardiac surgery patients	Quantitative A cohort observational study	N=59 post-cardiac surgery patients	<p>During noncaptive procedures T2, BPS scale was high in both rating nurses (T2 mean SD 4.35±0.90) by rater A and rater B T2 mean SD 4.38±0.94) also patients self-pain report NRS numeric self-scale (T2 mean SD 3.80±1.33).</p> <p>During all assessments Intraclass correlation coefficients &gt;0.86 for rater A and rater B.</p> <p>These results support the validity and reliability of BPS in pain assessment postcardiac surgery</p>	Jufo: Medicine 1 CASP: Question 1: yes Question 2: yes Question 3: yes Question 4: yes
5 Marie 2013 USA	To examine if the study done by Gelinias 2006 about the same topic is reliable and to	Quantitative	N=21 postoperative open-heart surgery patients	A significant difference in mean CPOT scores was noted during painful procedures (T2, T5 and T8) compared to non-painful procedure (T1, T4 and T7) supporting the	JUFO: Pain Management Nursing: 1 CASP

Appendix 2

2 (2)

	determine if CPOT is useful in pain assessment also to examine the interrater reliability (IRR), criterion validity (CV), and discriminant validity (DV) of the CPOT	Repeated measures design		discriminant validity of CPOT in detecting pain in open heart surgery patients	Question 1: yes Question 2: yes Question 3: yes Question 4: yes
6 Linde 2013 Rhode islands, USA	To identify if CPOT is a valid and reliable tool in pain assessment.	Quantitative a repeated-measure, within-subject design (ANOVA)	N=35 patients in the ICU unit post-operative open-heart surgery N= 2 nurse's raters	Mean CPOT score increased during Turning which is a painful procedure (increase, +3.04; 95% CI, 2.11-3.98; P<.001) while being stable during dressing which is a non-painful procedure (increase, +0.25; 95% CI, -0.07 to 0.57; P = .12) which indicates that CPOT is a valid and reliable method in pain assessment of non-verbal critically ill patients	JUFO: American journal of critical care: 1 CASP: Question 1: yes Question 2: yes Question 3: yes Question 4: yes
7 Boitor et al., 2016 Canada	To examine the validity of CPOT and vital signs in relation to pain	Quantitative A prospective repeated measurement study	N=125 post-operative cardiac surgery patients	Mean CPOT scores increased during nociceptive procedures such as Mediastinal Tube Removal (mean [SD], 2.74 [1.61]) compared to non-painful procedures (mean [SD], 0.50 [0.75]) also there was a correlation between CPOT scores and patients self-report (r = 0.419, P <.01).	JUFO: Journal of Cardiovascular Nursing: 1 CASP: Question 1: yes Question 2: yes Question 3: yes Question 4: yes

Appendix 2

2 (2)

<p>8 Rijkenberg et al., 2017 Netherlands</p>	<p>To determine if Critical Pain Observation Tool CPOT and Behavioral Pain Scale BPS are valid and reliable pain assessment in mechanically ventilated patients' postoperative open-heart surgery</p>	<p>Quantitative A prospective, observational cohort study</p>	<p>N=72 mechanically ventilated postcardiac surgery patients</p>	<p>After doing the measurements by two nurses the results show that the behavioral pain scale and critical pain observation tools are equal and reliable, intraclass correlation coefficients: 0.74 (95% confidence interval 0.68-0.79), p ¼ 0.001 also BPS and CPOT scores increased significantly by 2 points during painful procedures such as turning.  CPOT and BPS are reliable, Cronbach's alpha for CPOT was 0.65 and 0.58 for nurse 1 and 2 respectively, for BPS 0.62 and 0.59 nurse 1 and nurse 2 respectively</p>	<p>JUFO: Journal of Cardiothoracic and Vascular Anesthesia:1  CASP: Question 1: yes Question 2: yes Question 3: yes Question 4: yes</p>
<p>JBIC Critical Appraisal Tool cohort studies questions                  Question 1: Was the exposure measured in a valid and reliable way?                  Question 2: Were the exposures measured similarly to assign people to both exposed and unexposed groups?                  Question 3: Was appropriate statistical analysis used?                  Question 4: Were the groups/participants free of the outcome at the start of the study or at the moment of exposure?</p>					