COLLEGE SUTHERLAND AMSTERDAM

The effect of a General Osteopathic Treatment on the oxygenation of the upper limb performed on the Intensive Care Unit

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A dissertation submitted in partial fulfilment of the requirements for the degree of DO at College Sutherland for Osteopathic medicine at Amsterdam

Academic year: 2020

I. Acknowledgements

Where there is a will, there is a way. That was the motto while writing this thesis. Because we both are interested in the working of the human body, writing this thesis has only enriched our knowledge. The first part of this investigation took place in early 2016; we reworked part one in early 2020. Patrick Rodrigus was our promoter in the first part. The end result has grown from reading books and scientific articles, by exchanging thoughts, but sometimes by feeling frustrations too. We are coming to the end of the education in osteopathy, with this final thesis as its climax. We have been working on this project for months. A few people have been very important in writing this research. We want to thank them all from the bottom of our hearts for helping realize this work.

A word of thanks goes to doctor Bart Devos, for the continuous supervising and the constructive feedback.

To all nurses, thanks for all the good help during the interventions.

Thanks to Patrick Rodrigus, for the start-up and the answers to all our questions.

Thank you Maël, for all your humour in times of frustration. Thanks for the insights and reading this thesis several times.

Thanks to our families, we have felt the love every time.

The biggest thanks goes to our little daughter Ana, she is born while writing part one in 2016. She gave us so much love, every single day. Now all these years later, we are expecting our second daughter in May. Our pregnancy gave us perseverance to keep going. We never would have written this thesis like this without all these people and their support.

Thanks to all of you!

Knokke-Heist, May 2020

II. Statement of originality

This is to certify that to the best of our knowledge, the content of this thesis is our own work.

We certify that the intellectual content of this thesis is the product of our own work and, that all received assistance and used sources in preparing this thesis have been acknowledged.

Ghent,

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III. Abstract

OBJECTIVE: In critical care patients, it is necessary to monitor the vital parameters continuously. Changes in physiology may be noticed more quickly in this target group. In this research, the focus is on the oxygenation as parameter. The objective of this study is whether a general osteopathic treatment (GOT) performed on the upper limb, effects the oxygenation in intensive care unit (ICU) patients.

MATERIAL AND METHOD: Twenty critical care patients participated the investigation. GOT and a myofascial mobilization technique were randomly performed for 15 minutes as intervention. GOT has as primary aim to restore the physiology and homeostasis of the human body. The oxygen levels were measured by pulse oximetry (SpO2) and blood gas analyses (tHb, sO2 and pO2). The pulse oximeter was always attached to the fingertip. The blood gas analyser was the RapidPoint 500 (Siemens). The SpO2 was measured right before and after treatment. Blood samples were taken right before, after and one hour after treatment.

RESULTS: Three different parameters were measured by 60 blood samples, namely tHb, sO2 and pO2. The data for the three parameters were normally distributed. The difference between "GOT" and "Control" for sO2 was not statistically significant, but had a remarkable value compared to the other. The value was still too high to reject the null hypothesis. It was not possible to draw conclusions about the SpO2 values.

CONCLUSION: Based on the results, we cannot conclude whether GOT has effects on the oxygenation. The different values obtained by the pulse oximeter and the blood gas analyses are difficult to interpret because of the small sample size of this pilot study. In a follow-up study, it is important to investigate with a bigger sample size and to analyse on more physiological parameters. This pilot study is a starting signal for further investigation.

KEYWORDS: General Osteopathic Treatment (GOT), Oxygenation, Oxygen saturation, (Passive) Mobilization, Intensive Care Unit (ICU), Manual therapy, Upper limb, Pulse oximeter, Blood gas analysis system, RapidPoint 500

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1 Introduction

Ever since Andrew Taylor Still have laid the foundations for the osteopathic view on the human body, osteopathy as a treatment method has become an integral part of the current medical care (Booth, 2018). There is more and more interest in complementary and alternative healing methods, in both caregivers and patients themselves. As A.T. Still once put nicely in his book The Philosophy and Mechanical Principles of Osteopathy: "“We look at the body in health as meaning perfection and harmony, not in one part, but in the whole.” This is how people approach treating in the present. Holism is a core principle in the osteopathy, and is increasingly being continued in determining of treatment strategies (Collinge, 2009). Not only are they looking for treatment options within the classical medical world, paramedical lines of thought are implemented nowadays as a possible treatment or addition too. It is no longer a story in which one medical discipline leads to the solution, it has become a story in which multiple disciplines work together to achieve an optimal end result.

This holistic way of thinking will be continued throughout this thesis where a paramedical treatment is applied in a medical setting. An example of a paramedical treatment is a General Osteopathic Treatment (GOT) developed by John Martin Littlejohn (Wernham, 1996), a student of A.T. Still. It is Littlejohn who has brought osteopathy to Europe. GOT is a passive long lever mobilization technique that is performed at the limit of movement (Fieuw, Noelmans & Van Dun, 2002). In this form of mobilization, the patient does not use his muscles actively; it is the osteopath who induces the movement. It happens rhythmically with circumduction and pain free. Pain free because they do not want to provoke extra stimulation of the sympathetic activity (Peeters & Lason, 2014). Each joint of the body has its own GOT technique. The primary focus of a GOT is not increasing the range of motion of a joint, but restoring the physiology and homeostasis (Parsons & Marcer, 2005).

An essential element within the physiology is oxygen (O2). O2 is tightly regulated within the body, because a human individual needs O2 to function well. Hypoxemia can lead to many acute adverse effects on various organ systems (Hafen & Sharma, 2020). There is a continuous transport of O2 using the

erythrocytes. Haemoglobin (Hb) is a protein present in the erythrocytes that can bind O2. The connection between O2 and Hb is called oxyhaemoglobin. The bound O2 molecules are then transported by the erythrocytes to the cells in the body and unleashed there. After delivery, the Hb is called deoxyhaemoglobin (Mediscs4Medics, 2019). Arterial oxygen saturation measures the amount of Hb currently bound to O2 compared to the amount of Hb unbound (Hafen & Sharma, 2020). The value is always expressed as a percentage (de la Merced Díaz-González, de la Rosa-Hormiga, Ramal-López, González-Henríquez, & Marrero-Morales, 2017). The normal value of the arterial O2 percentage is higher than 95%. When the saturation drops below 90%, it is called desaturation (Demin, Geysenbergh & Wegge, 2019). The arterial oxygen saturation can be measured by a non-invasive method, namely pulse oximetry (SpO2). An invasive measurement method is arterial blood gas analysis (SaO2) (Ebmeier et al., 2018). Measuring the oxygen saturation is a vital parameter (de la Merced Díaz-González et al., 2017). Continuous monitoring and interpreting these vital parameters are a standard routine in the Intensive Care Unit (ICU) (Ebmeier et al., 2018). Patients admitted in ICU are people where one or more vital functions are disrupted and are therefore in need of continuous monitoring. Pathologies and immobility can hinder the normal flow of vital fluids, which include blood circulation (Davenport, 2018). Because our focus is lying on influencing the parameter oxygenation, we have looked for a target group in which the oxygenation possibly fluctuates and needs to be continuously monitored. Also the long-lasting immobility of the patients has been a reason to choose for this critical group. Circulation stagnates around an immobile joint and thus adds to the trouble. The vicious circle of immobility on ICU has to break (Fontela, Lisboa, Forgiarini-Júnior, & Friedman, 2018). Castro-Avila, Serón, Fan, Gaete, and Mickan (2015) describe mobilization on ICU patients as a physical activity with the aim obtaining physiological benefits like an improved central and peripheral circulation. Needham, Truong, and Fan (2009) have done an investigation whether passive mobilization can improve the muscle strength and the functionality of the patient on ICU. They have applied neuromuscular electrical stimulation (NMES) while performing passive exercises. The investigators have discovered that passive mobilization of the limbs combined with NMES improves the oxygenation by an improved intramuscular blood flow. Cruz-Montecinos et al. (2017) have studied the immediate effect of a soft tissue manual therapy protocol (STMTP) on lung function in chronic obstructive pulmonary disease

(COPD) patients. The techniques have been performed on the thorax and diaphragm. The SpO2 has been measured immediately before and after administration of the STMTP. A single application of an STMTP seems to show improvements in long function. An increase of SpO2 is measured. Passive mobilization techniques seem to trigger the human physiology.

Oxygen saturation and GOT can be combined in a research. To the best of our knowledge, no specific studies can be found in this regard, but it seems interesting to take note of this. In this thesis, a pilot study is conducted in which a new task is tested that will aim to answer these kinds of questions. For this it is essential to start exploring in literature the concepts GOT and oxygen saturation first before they can be merged together. The research question can be adequately formulated and answered on the basis of existing literature.

General Osteopathic Treatment

In general, not much information has been published on the GOT, certainly information about this technique in scientific articles is very limited (Johnston, 2015). Based on Littlejohn's theory, Luc Peeters and Grégoire Lason have formulated the concept GOT in a specific document for the International Academy of Osteopathy (IAO). It is described as a general osteopathic mobilization technique based on the standard osteopathic principles (Peeters & Lason, 2014). The first fundamental principle of osteopathy, where GOT is based on, is described by A.T. Still, namely that the structure affects the function and vice versa (Tozzi, Fusco, Lunghi, & Hruby, 2017). The human body needs to be in a mechanically good condition to function well. The mobility of all articulations will be tested while treating. The osteopath can judge the joints on a good or rather poor range of motion (Peeters & Lason, 2014). Mobilization of the structure causes more than just an increased result in articular mobility; it has an influence on the soft tissues too. Not only the articulations will be evaluated on range of motion, tensions in the myofascial system can be evaluated too. A myofascial system in temporary or chronic contraction can cause adjustment or compensation reactions. A contraction in the human body causes loss of movement in the soft structures, which can disturb the supply of nutrients and cause an accumulation of waste (Tasker, 2006). During the GOT a vasodilation of the peripheral circulatory system will be created. During vasodilation the supply

of oxygen and the drainage of fluids will pass better, because the blood goes to the muscles in action (Kenney, Wilmore, & Costill, 2019). This is what A.T. Still has named 'the arterial rule' (Collinge, 2009). A.T. Still cites "The rule of the artery must be absolute, universal and unobstructed, or disease will be the result". It represents the second principle in the osteopathy (Booth, 2018). This makes it essential to perform a GOT as a systematic and stretching mobilisation on all articulations as nearly as possible through their normal range of motion. The osteopath will manually correct mechanical abnormalities of soft structures. Physiological recovery must be achieved (Rule, 1938). A GOT is founded on different principles. The focus of the IAO is on three parameters: routine, rhythm and rotation. The therapist accentuates these parameters while doing a GOT (Peeters & Lason, 2014). While other sources in literature describe not only these three but even more parameters where they focus on.

Routine is the first parameter. By continuous repeating a movement the osteopath is able to evaluate the quality of the joint and the soft tissue on progress or decline. Directions that move more difficult than other directions will stand out (Parsons & Marcer, 2005). By routine it is perfectly possible to adjust the technique to the loss of motion of that articulation (Fieuw et al., 2002). Furthermore, the repetition of the movement causes improvement in proprioception, and it induces a way of neuromotorial reprogramming (Peeters & Lason, 2014). Rhythm is the parameter that gives regularity in the mobilizations. Along with routine, rhythm influences the central nervous system. The implementation of an on-going motion in a certain rhythm leads to sort of a pump mechanism that drains the joint of waste materials (Peeters & Lason, 2014). The osteopath focuses on the presence of rhythms within the body of the patient, or within his own body. Each patient has an own individual rhythm (Comeaux, 2008). Alterations of rhythm may be present as tension, oedema, rigidity et cetera. The osteopath can easily notice these changes (Fieuw et al., 2002). If the osteopath cannot locate any kind of rhythm, it is considered important to normalize this onto the patient (Parsons & Marcer, 2005). The mobilization has to be performed on the rhythm that fits the patient, because a GOT can inhibit the structure or stimulate the structure (Fieuw et al., 2002). During a GOT all the movements of the joint take place in a rotation by using the limbs as long levers until the normal range of motion is achieved (Fieuw et al., 2002). Rotation is the third parameter. A circumduction gives the osteopath the

possibility to evaluate the range and the mobility of the joints and the soft tissues around that joint (Peeters & Lason, 2014). The osteopath works with a rotatory manner by circumducting the joints through their full range of normal motion (Parsons & Marcer, 2005).

Other parameters where the International Academy of Osteopathy does not speak of in their course but can be found again in other sources are mobility, motility, articular integrity, coordination, correlation, stabilization and mechanical laws. Mobility is important on cellular level one side and on macro levels other side. Any loss or reduction of mobility sets up the process of an altered structure and reduced functionality. Without treatment leads this in time to a diseased state. Discovering a dysfunction is possible with testing the mobility (Fieuw et al., 2002; Parsons & Marcer, 2005). Motility is a form of movement controlled by the autonomic nervous system, so considered not to be under voluntary control. Littlejohn has already early been aware of an underlying involuntary movement to the brain and the spinal nervous tissues (Parsons & Marcer, 2005). The integrity of an articulation encompasses the shape of a joint, the muscle tone and the tension of ligamentous structures. Applying mobility and motility on a joint can repair the articular integrity. Coordination stands for the balance of the different systems. When it is balanced it brings unity to the human body. There is also coordination between the osteopath and the patient during the treatment. The correlation refers to the interdependence of all structures upon one another. A structure needs supplies in order to function, so the correlation of innervation, nutrition and drainage of fluids is important. Stabilization of the body is provided by coordination and correlation. It is the cooperation between these two that leads to homeostasis. Within the GOT, normalizing the homeostasis is one of the primary aims. Purely mechanical, a GOT aims to repair the mobility of joints that have reduced movement, what benefits the function. But a GOT affects more than only an improvement in mobility. The mobilizations have a rhythmic and rotatory routine what improves the mobility of fluids and reducing stasis of waste. There is not just an effect on the musculoskeletal system, also on the vascular and lymphatic function. A GOT is a technique with a long lever and the mobilization of the articulation is directed from the periphery towards the centre of the body to improve drainage (Parsons & Marcer, 2005).

Oxygen saturation

In scientific articles, the terms oxygen saturation and oxygenation are frequently used mixed. In medicine, they refer to the same, the amount of O2 bound to haemoglobin in the red blood cells of the arteries (TNI Medical). It is necessary to differentiate between invasive and non-invasive methods to measure the oxygen (Demin et al., 2019). The most commonly used non-invasive measurement method is pulse oximetry, measuring percutaneous the arterial haemoglobin saturation (SpO2) in the peripheral capillaries (Seifi, Khatony, Moradi, Abdi, & Najafi, 2018). This method of technology is indispensable in the present-day practice; it is easy to use and not extra expensive (List, van Velzen & de Pont, 2019). It makes an early diagnosis of hypoxemia possible (Tusman, Bohm, & Suarez-Sipmann, 2017). An invasive method to measure the oxygen saturation is by arterial blood gas analysis. A blood sample is taken to test the oxygen percentage. An array of parameters can be determined with an arterial blood gas analysis, among them the exact arterial oxygen saturation (SaO2) (Demin et al., 2019). Blood gases are regularly taken at the ICU. The device present at the unit analyses the values in a few seconds. It is important to notice that monitoring the oxygenation by pulse oximetry contains a list of possible influencing factors; therefore it cannot guarantee a 100% accurate analysis (Jubran, 2015). For this reason, it stays necessary to perform an arterial blood gas analysis on regular base. In general, an arterial blood gas analysis is accepted as the most accurate because of the direct measurement on the blood (Yönt, Korhan, & Khorshid, 2011). It is the gold standard daily used in critical patients at the ICU (Ebmeier et al., 2018).

There are several factors influencing the oxygenation, one by one conditions where an increased supply of oxygen is needed. There are a few scientific articles bringing up some of these factors in detail. An example is hyperbaric oxygen therapy (HBOT). During a HBOT, the patient breathes in pure oxygen under high pressure through a tube. This kind of treatment is applied to people with severe infections, diabetic foot ulcers, vascular dementia, air bubbles founded in blood vessels, et cetera (Xiao, Wang, Jiang, & Luo, 2012). HBOT is also used to treat decompression on divers. The air pressure is three times higher than normal; this gives the lungs the opportunity to incorporate a bigger amount of oxygen in blood (Kranke, Bennett, Roeckl-Wiedmann, & Debus, 2002). Anaemia is a

condition in which the quality or quantity of circulating erythrocytes is reduced below a normal level (DeMaeyer, 1989). The quality of erythrocytes can be determined, among other things, by the concentration of haemoglobin (Hb). The quantity of circulating erythrocytes is dependent by the amount per volume blood. The main consequence of anaemia is a reduced oxygen-carrying capacity of the blood (Gliwitzki, Gross, Pietrzik, Winoto, & Sastroamidjojo, 1997). The oxygenation can also change during human effort due to various local adjustments in the muscles, there takes place an increased metabolic rate. Haemoglobin will release faster its O2 molecules due to different changes, which makes it easier absorbing oxygen in the muscles (Kenney et al., 2019).

Osteopathy and oxygen saturation combined?

To the best of our knowledge, no many previous scientific investigations in which osteopathy is combined with measuring the oxygenation have been done. A few small studies are showing beneficial effects on the oxygenation. Shi et al. (2011) have investigated if cranial Osteopathic Manipulative Medicine (OMM) has effect on as example the cerebral tissue oxygen saturation (S(CT)O(2)). The possible effects could play a role in maintaining the cerebral homeostasis. They have applied randomly augmentation and suppression techniques and sham therapy to healthy adults. Measurements shall be carried out before, during and after applications of the techniques. The data suggest that the suppression technique elicits a mild but statistically significant reduction of the S(CT)O(2). Which means that this technique, applied to conditions like intracranial hypertension, might provide relief. Manzotti et al. (2020) have investigated if an Osteopathic Manipulative Treatment (OMT) has immediate effects on physiological measurements in preterm new-borns, such as partial oxygen saturation (SpO2). They want to compare the values with ten minutes of static touch. OMT has caused an increase of SpO2. The results of the study suggest that an OMT has positive effects on preterm physiological parameters. Genc, Koca, and Gunerli (2014) have done an investigation whether passive limb exercises (PLE) have effects on respiratory and hemodynamic parameters in critically ill patients. They have among other things recorded the percutaneous oxygen saturation (SpO2) before and after applying the specific mobilization exercises. The study shows the benefits of mobilization on the improvement of oxygenation.

To our knowledge, no specific studies have been done concerning the oxygenation combined to a GOT. Combinations with other osteopathic treatment techniques have been found, as mentioned above. This current thesis attempts to investigate what influence a GOT performed on the upper limb has on the oxygenation in ICU patients. We have chosen for the whole chain of the upper limb because the arm is located close to the heart. It has a lot of attachments with very important nerve and blood supply around it. A bad mobility of the shoulder joint can cause pressure upon the sympathic ganglion and all the nerve and blood supply over there. That kind of malfunction can affect the pump function of the heart (Davenport, 2018). A pilot study will be set up to explore this topic first. A pilot study is a small investigation to find out whether lager investigation is useful. Twenty patients in critical care have taken part in this study, complying with strict in- and exclusion criteria. Half of them have been intervention group, the other half control group. The distribution is determined by randomized picking. The hypothesis that GOT performed on the upper limb has effect on the physiological parameter oxygen saturation, could mean GOT is a treatment method that possibly helps controlling the homeostasis of the human body. The purpose of the study is thus to test the effect of a GOT on the oxygen levels, and to compare it with the effect on the oxygen levels after fifteen minutes myofascial mobilization. In case the GOT would have effects on the oxygen saturation, this would mean a moving forward in the field of osteopathy.

2 Material and Method

2.1 Setting and population

The investigation was carried out in the Intensive Care Unit (ICU) of AZ Zeno, campus Knokke (Belgium). First of all, the ethics committee of AZ Zeno approved the study. The ICU in Knokke had capacity for six critical ill patients, with in every room a ventilator. The therapy took place in the morning between nine and half past eleven. The interventions were spread over two months, during the winter of 2016. Twenty subjects were recruited. There participated 50% men and 50% women to avoid possible physiological differences that could affect the investigation. The participants did not receive compensation. The patients were staying in ICU because of critical health problems, or because of a surgery earlier that week. To be including in the study the participants must comply with strict in- and exclusion criteria, what reduced our sample size. In the end, the age was between thirty and eighty years old.

Inclusion criteria:

- age 18 years and over;
- arterial line already present;
- patient mentally competent to give their permission;
- pulse oximeter present on the fingertip.

Exclusion criteria:

- signal strength of SpO2 <50% (no problems with the sensor);
- patient placed in isolation;
- patient who had surgery that day or the day before (for safety);
- no administration of vasoactive drugs;
- no administration of (extra) O2.

Only mentally competent adults participated the investigation. No children took part because we first wanted to analyse the results in adults. An arterial line for arterial blood gas analysis was present in all patients. Sticking a new arterial line for each patient was impossible and too invasive (List et al., 2019). With pulse oximeters, every artery (peripheral) is theoretically sufficient to measure

the SpO2 (Jubran, 2015). In this thesis, the clip was attached to the fingertip of the right or the left hand. We opted for the fingertip, because the path of the arteries is not so long as, for example the path of the arteries from the toes (Putz, 2009). The right hand is supplied with blood from the first branch of the aorta and the left hand is supplied by blood from the third branch of the aorta (Brink, Lindsen, & van den Brink, 2016).

Ebmeier et al. (2018) their investigation concluded that in case of desaturation pulse oximeters possibly reflect the SpO2 percentage lower than the effective SaO2 percentage. The safety of the patient was priority in low oxygen levels. Critical patients in isolation were excluded from this thesis to prevent any further spread of the disease. Vasoactive drugs are medication to stabilize the heart rate and blood pressure. These kinds of drugs could influence the homeostasis of the oxygenation (Boerma & Ince, 2010). Oxygen therapy is a way to provide oxygen and is indicated in patients with oxygen saturations below the normal saturation range (Pilcher & Beasley, 2015). Extra oxygen logically affects the saturation and so the obtained results.

A written informed consent must be signed by the patient to participate the research. The document was read out loud. Afterwards they had the ability to reread the document before signing. All patients continued receiving routine clinical care during the study period.

2.2 Study design

Because this study was the first one investigating the mentioned hypothesis, we performed a pilot study. Twenty ICU patients were randomized into an intervention group (n=10) and a control group (n=10). The intervention group received a GOT and the control group received a minimal myofascial treatment. The results of the oxygen saturation were obtained by a pulse oximeter (SpO2) and a blood gas analysis system (SaO2). The arterial line was already placed.

2.3 Procedure

To make the research as accurate as possible, we passed through a specific procedure. The participant could be treated by a GOT or a myofascial mobilization. Which treatment the patient would receive, was in advance decided by randomized picking. First of all we read out loud the informed consent, the patient was invited to ask questions and could reread the document if required. The participants were asked to complete the informed consent in which they explain to participate voluntarily and in which is communicated they are free to end the experiment at any time during the treatment. Only their signature could confirm the approval. The age of the participant was asked in advance. For the whole procedure was one nurse, one osteopath and one doctor to supervise needed every time. The doctor was B.D. and for the osteopaths was alternation between N.D. and C.L. Who was the nurse depended on who was on duty that day. All patients received kinesitherapeutic treatments daily, what made the intervention for some of them less new. Before starting the treatment (in both GOT or placebo), blood was drawn through an arterial line and the oxygenation was measured by a pulse oximeter. The patient received one of the two treatments for fifteen minutes immediately afterwards. A second time blood was taken right after intervention, and the oxygen saturation was recorded again. One hour after treating, blood was taken for the third time. The result of the pulse oximeter (SpO2) was not checked again.

2.3.1 Randomised picking

Which treatment was given, was decided by a 'randomised picking trial'. There were made twenty envelopes with each a different sheet of paper. Ten envelopes were for women, ten other for men. So there were two different stacks of envelopes. On five of the paper sheets was written 'General Osteopathic Treatment'; on the other five was written 'Control treatment'. The envelopes are randomly shuffled and then numbered. Before the treatment started, the practitioner opened only one envelope depending on gender, to know which mobilization he must perform. The participants did not know whether they received the real or control treatment.

2.4 The intervention

The intervention consisted of two different therapies, namely a GOT or a myofascial mobilization. The ICU of Knokke decided to give us fifteen minutes per patient. In literature we found similar durations for osteopathic treatments during investigations, always around twenty minutes per intervention (Andrea Manzottia et al., 2020; F. Comhaire et al., 2015).

2.4.1 General Osteopathic Treatment

Half of the participants received a GOT. The practitioner performed five different GOT techniques on the joints of the upper limb. The mobilization techniques passed fluently into each other. The GOT was performed with the participant in neutral supine position, the osteopath standing on the homolateral side. De practitioner worked with a mobilizing hand and a stabilizing hand. The possible range of motion was always tested (Fieuw et al., 2002). The whole treatment lasted fifteen minutes. The fifteen minutes were divided into five times three minutes. All of the five techniques were each conducted for three minutes. The sternoclavicular, the acromioclavicular, the glenohumeral, the radioulnar and the metacarpophalangeal joints were treated. Each movement was fluently and rhythmic performed with circumduction. This relaxed the tissues and frees up the general circulation (Murray, 2013). There exists different GOT methods to mobilize the upper limb, also different positions for the patient, but in this thesis were used the following techniques all in neutral supine position given the situation of an ICU patient:

2.4.1.1 Sternoclavicular articulation

The therapist fixed the homolateral hand of the patient against his shoulder. He fixed with his other hand the sternum and the first rib to posterior. The therapist made circulatory movements with his entire body in the sagittal plane of the patient (Peeters & Lason, 2014). The fascia of the neck was stretched (Fieuw et al., 2002). This mobilization was applied for three minutes.

2.4.1.2 Acromioclavicular articulation

The therapist fixed the homolateral hand of the patient against his shoulder. With his other hand he comprised the posterolateral side of the clavicle. He put in an on-going craniocaudal movement with the arm of the patient. During the caudal movement, the therapist gave anterocaudal traction to the clavicle (Peeters & Lason, 2014). This movement was repeatedly applied for three minutes.

2.4.1.3 Glenohumeral articulation

The therapist fixed the homolateral hand of the patient against his shoulder. With his other hand he comprised the acromion and the scapular spine. He put in an on-going craniocaudal movement with the arm of the patient. During the caudal movement, the therapist gave anterocaudal traction to the posterior side of the scapula (near the scapular spine). During the cranial movement, he increased pressure to posterior on the acromion (Peeters & Lason, 2014). The humerus was moved in all directions in the glenoid fossa (Fieuw et al., 2002). This movement was repeatedly applied for three minutes.

2.4.1.4 Radioulnar articulation

The therapist comprised the proximal part of the forearm. By making an anteroposterior binding motion, he moved the radius towards the ulna. This technique was also performed just above the wrist (Peeters & Lason, 2014). This movement was repeatedly applied for three minutes.

2.4.1.5 Metacarpophalangeal articulations

The therapist comprised the hand of the patient, and put in a movement between the metacarpophalangeal articulations. The accentuation was both on metacarpophalangeal one-two and on metacarpophalangeal four-five (Peeters & Lason, 2014). The palmar fascia was stretched too (Fieuw et al., 2002). This movement was repeatedly applied for three minutes.

2.4.2 Myofascial mobilization technique

Half of the ICU patients were control group, treated by a minimal myofascial treatment of the upper limb as "placebo". We mark placebo in quotation marks because it is often implying a treatment without effect (Bialosky, Bishop, & Penza, 2017), while every kind of touch has its effect on the human body. In Osteopathy has the word touch a fundamental role (McGlone, Cerritelli, Walker, & Esteves, 2017). The focus of an osteopath performing GOT is different than during a myofascial treatment (Manzottia et al., 2020). Myofascial treatment techniques are a part of manual therapy (Cruz-Montecinos et al., 2017). The techniques were passive performed very softly and without a rhythmic movement (McKenney, Elder, Elder, & Hutchins, 2013). The treatment could be compared to a gentle massage. The aim of the myofascial technique was to relax the fascia of the upper limb. There are many different treatments that fall under myofascial therapy, so it is important to clarify which mobilization was being performed here. The practitioner was standing homolateral and took with both hands the upper arm close to the armpit. Both thumbs were placed on the anterior side of the upper arm and gave very soft pressure on the skin, while going slowly lower. Afterwards he did the same at the anterior side of the forearm. The myofascial treatment lasted fifteen minutes.

2.5 Measuring instruments

Two devices were used to determine the parameters: pulse oximetry (SpO2) and blood gas analysis (tHb, sO2 and pO2). We opted for a non-invasive and an invasive method.

2.5.1 Pulse oximetry

Pulse oximeters are small monitors, completely non-invasive. The most commonly used location to attach the clip is the fingertip (Demin et al., 2019). Takuo Aoyagi developed the pulse oximeter technology in 1972 (Severinghaus, 2007). In the critical care of AZ Zeno (Knokke) they used the Nellcor Oximax SpO2 finger sensor (Minneapolis MN, USA). Each side of the pulse oximeter clip has a

light sensor. They are facing each other. The first sensor is the transmitter who beams two wavelengths of light (red and infrared) to measure oxygen levels (SpO2) and the pulse rate. The second sensor is the detector who detects how much light is being absorbed (Jubran, 2015). By comparing the amount of transmitted and absorbed light (red and infrared), it is possible to make a provision of the oxyhaemoglobin and deoxyhaemoglobin (Tusman et al., 2017). The amounts of oxyhaemoglobin versus deoxyhaemoglobin determine the level of saturation. If there is only deoxyhaemoglobin in the blood, the SpO2 is 0%. In the ICU the pulse oximeter is connected to a personal monitor of the patient. The values of the SpO2 and pulse rate create graphics on the monitor to evaluate spectacular changes.

In some clinical and technical situations, it can happen that the pulse oximeter shows inaccurate results by influencing factors. Several scientific articles confirm these factors. Lam et al. (2017) describe that desaturation can influence the accuracy of SpO2. A higher concentration of deoxyhaemoglobin will cause malfunction. According to Ebmeier et al. (2018), skin pigmentation can disturb the results of SpO2. Differences in SpO2 are measured between different skin colours. Movement has a big impact on the reliability of pulse oximetry. The light sensors located on the skin of the fingertip move and that gives malfunction. The detector is not able to differentiate between the pulsations of movement or the real arterial pulsations. Movement is difficult to filter out because of the unpredictability (Jubran, 2015). Deficient peripheral blood flow by, for example hypotension or hypothermia, can give less pulsatility of the artery. This can cause episodes of no oxygen measurements and consequently disturb the SpO2 result (Lam et al., 2017). Large amounts of Hb derivatives present in the blood can disrupt the light sensor and cause errors of SpO2 (Nitzan, Romem, & Koppel, 2014). Vasoactive drugs are clinically used to stabilize abnormal haemodynamic conditions, and to decrease derangements in oxygenation. This kind of medication affects the SpO2 results (Boerma & Ince, 2010).

In this investigation, the SpO2 results were verified twice, one time before and one time after the intervention.

2.5.2 RapidPoint 500(®)

Arterial blood gas analyses are called the gold standard for measuring the O2 saturation; they are widely accepted being the most accurate because of the direct measurement on blood (Yönt et al., 2011). The process is invasive and can only be performed by skilled workers. A heparinized syringe is filled by fresh drawn blood for 200 microliters. Heparin is artificial used to slow down the blood clotting (Bowen & Remaley, 2014). The blood was taken via an arterial catheter. That catheter was already present, so the patient experienced no extra discomforts. The ICU of AZ Zeno Knokke was daily working with the RAPIDPoint 500 (®) blood gas systems, designed by Siemens technology. These systems deliver test results in approximately one minute, which is fast. The RAPIDPoint 500 (®) can analyse the blood gas (pH, pCO2, pO2), electrolytes (Na+, K+, Ca++, Cl-), metabolites (glucose, lactate), CO-oximetry (tHb, HHb, O2Hb, sO2, COHb, MetHb), pleural fluid pH and neonatal total bilirubin (Nicolas, Cabrolier, Bardonnet, & Davani, 2013). The parameters tHb (total amount of haemoglobin), the exact value of sO2 (oxygen saturation) and pO2 (partial pressure of oxygen) were the measured parameters selected for this research. When pO2 would amount 100 mmHg, the haemoglobin would be 100% saturated with oxygen. If pO2 would decrease, the percentage of saturated haemoglobin would decrease too (Hafen & Sharma, 2020). All parameters were automatically determined for each measurement. The device soaked up the blood sample; it was not injected. After processing the results, the device started washing the pipes to remove all blood residues of the patient. Air bubbles or clots could influence or even make fail the analysis. The analyser calibrated several times a day. Calibration was important to ensure accurate measurements. The kind of calibrations were a 1-point calibration every 30 min, a 2-point calibration every 2 hours, and a complete calibration every 8 hours (Allardet-Servent et al., 2017).

2.6 Data collection and statistical analysis

SpO2 (%) was monitored by the pulse oximeter attached to the fingertip; the RapidPoint 500 (®) blood gas analyser determined the value of tHb (g/dL), sO2 (%) and pO2 (mmHg). First of all, descriptive data were measured to get a general idea of the data collection. In this investigation three blood samples per

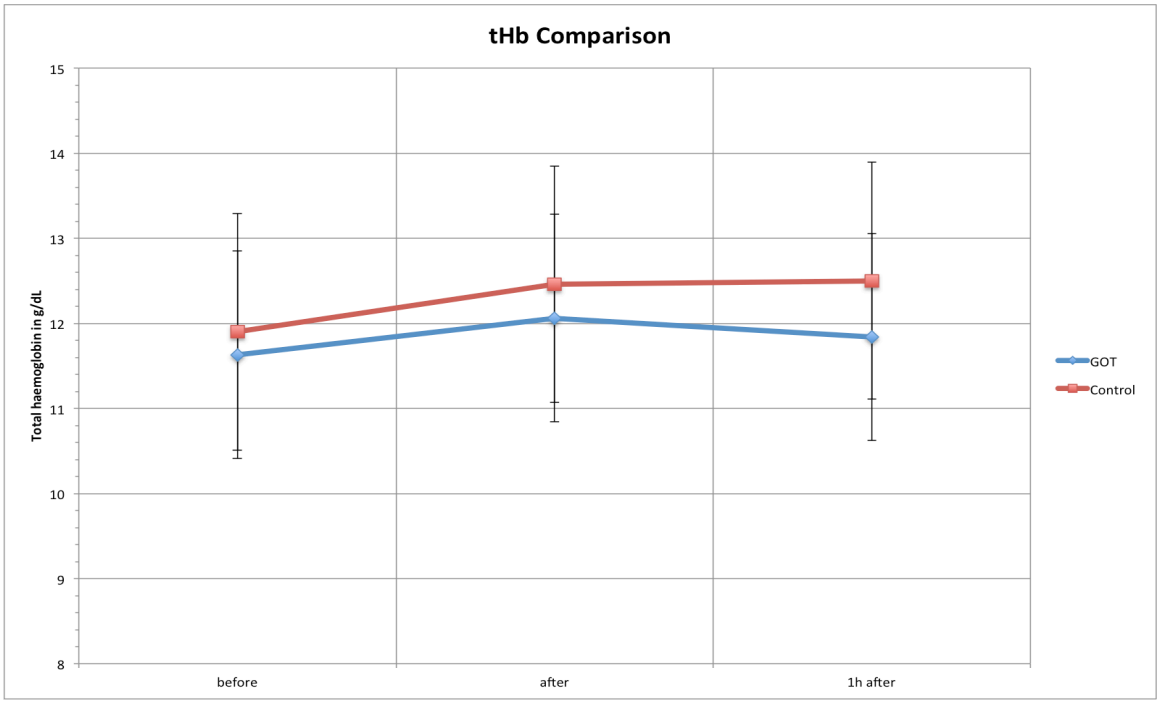
participant were analysed by the RapidPoint 500: before treatment (“before”), after treatment (“after”) and one hour after treatment (“1h after”). The statistics were divided into two groups of each ten participants; the first group received a General Osteopathic Treatment (“GOT”), the second group received a myofascial treatment (“Control”). Each patient was given a number from one to twenty, so there was no personal information known. Participants one to ten belonged to the group “GOT” and participants eleven to twenty belonged to the group “Control”. All results were noted on-site and placed in a table (Annexes 7.5).

All data were recorded in a Microsoft Excel spread sheet and analysed by the MedCalc statistical program (Schoonjans, Zalata, Depuydt, & Comhaire, 1995). First of all, the sample mean and standard deviation were calculated. Next, the Shapiro-Wilk test was used in both measurement methods to determine whether the data were normally distributed. We computed the 95% confidence interval (CI) for the mean, assuming a Student’s t-distribution for the mean. The CI for the population mean was calculated by the “CONFIDENCE.T” function on Excel. The intervals gave us an impression of how the data were different from one another. Because there was normal distribution within the results of the blood gas analyses, the Welch’s t-test was used to see if the means of “GOT” and “control” were different. The p-values clarified whether there was a significant difference. The Mann-Whitney U test was used to interpret the data of SpO2, because the p-value of “GOT” indicated that the values were likely not to be normally distributed. This test was measured on the median and gave no assumptions about underlying distributions. The p-values were judged at a 0,05 significance level α. We used two tailed tests to detect whether the values produced with or without treatment come from different distributions.

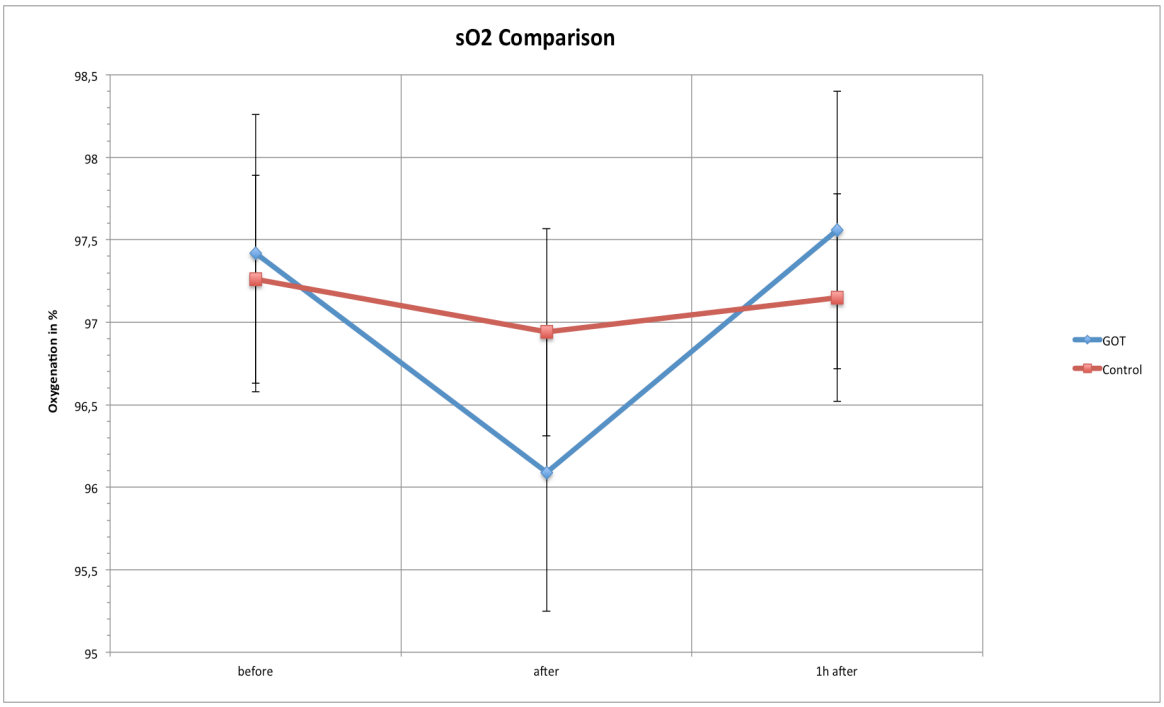
3 Results

3.1 Blood gas analyses

There are 60 blood samples analysed in total: 20 taken before the intervention (“before”), 20 taken right after the intervention (“after”), and 20 taken one hour after (“1h after”). All 60 samples are used in this research. The RapidPoint 500 blood gas analyser measures three parameters: tHb (total amount of haemoglobin), sO2 (oxygen saturation) and pO2 (partial pressure of oxygen). The results of each parameter are separately compared in a graph between the intervention group (“GOT”) and the control group (“Control”). The three comparisons are shown in following graphs (Graph 1, Graph 2 and Graph 3). They show the sample mean and the 95% confidence interval (CI).



Graph 1. tHb comparison between intervention and control group



Graph 2. sO2 comparison between intervention and control group

Graph 3. pO2 comparison between intervention and control group

Based on the graphs, the averages of “before” are almost equal for “GOT” and “Control”. The averages of “after”, for the values of pO2 and sO2, are lower for “GOT” than for “Control”. The graph of tHb shows no great movements. More specific tests in MedCalc are necessary to check whether the differences in average were significant or not. The graph of sO2 gave us a suspicion that the oxygenation would decrease after a GOT.

There is tested whether the distributions of “GOT” and “Control” are different for both the “after minus before” and the “1h after minus before” measurements. The Shapiro-Wilk test is used to test the normality of the data. We cannot reject the hypothesis of normality, so we proceed assuming the data is normally distributed. We use a Welch’s unequal variance t-test to check whether the distributions between “GOT” and “Control” are different. If this test can be rejected with confidence level 0.05, we can conclude that the distributions have different means, and consequently that the intervention has had an effect. The following table (table 1) shows an overview of all p-values. The minus refers to the difference between “after” and “before”, and “1h after” and “before”.

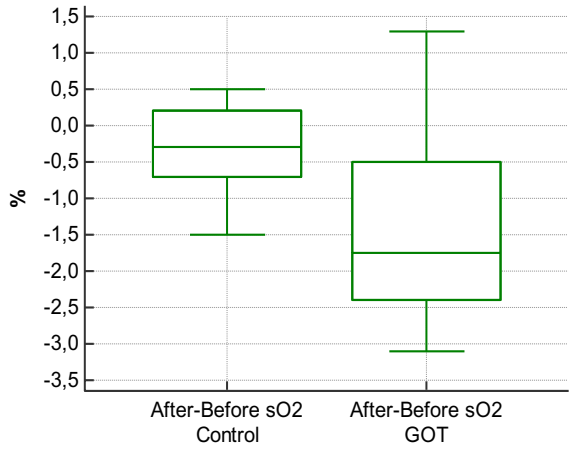
	After minus before			1h after minus before		
	Shapiro-Wilk “Control”	Shapiro-Wilk “GOT”	Welch’s t-test	Shapiro-Wilk “Control”	Shapiro-Wilk “GOT”	Welch’s t-test
tHb	p=0,7311	p=0,0635	p= 0,7093	p=0,3026	p=0,3182	p= 0,4162
sO2	p=0,6979	p=0,4195	p= 0,0661	p=0,7039	p=0,1091	p= 0,5788
pO2	p=0,7228	p=0,4852	p= 0,8278	p=0,1623	p=0,9799	p= 0,6697

Table 1. Overview of all p-values obtained by the results of the blood gas analyses with α*=0,05*

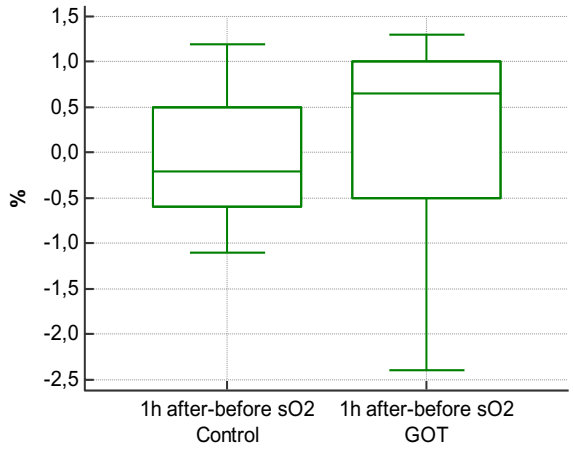
All p-values found in Table 1 are larger than the significance level α=0,05, which indicates that the null hypothesis cannot be rejected. Two p-values stand out, namely p=0,0635 (tHb) and p=0,0661 (sO2). The p-value of Thb “after minus

before" obtained by the Shapiro-Wilk test ("GOT") is close to rejection threshold. This could indicate a higher uncertainty about the normality of the distribution, and thus a higher chance of making a type II error (Faber & Fonseca, 2014). The p-value of sO2 "after minus before" obtained by the Welch's t-test is more striking for this investigation. The extreme value p=0,0661 could possibly indicate a difference between "GOT" and "Control", but the value is still too high to reject the null hypothesis. Larger investigation is needed to draw conclusions.

Because the results of sO2 have been the most relevant to this research, two additional boxplots of the sO2 results are shown below. Boxplot 1 shows the comparison between "GOT" and "Control" for the sO2 value "after minus before". Boxplot 2 is the comparison of "1h after minus before". The value of sO2 during "before minus after" shows a decline, but the p-value is not significant. The null hypothesis cannot be rejected, which means we potentially make a type II error by wrongly failing to reject the null hypothesis. Further investigation is needed. An overview of all tests can be found in the Annexes.



Boxplot 1. Results of sO2 after minus before



Boxplot 2. Results of sO2 1h after minus before

3.2 Pulse oximetry

The same analysis is performed to interpret the results of the pulse oximeter (SpO2, %). The results were noted immediately before and immediately after treatment (Annex 8.5.4). The Shapiro-Wilk test is used to determine the normality of distribution (Table 2). For the difference between "after" and "before" of "GOT", the normality is rejected (p=0,0403), so it is not an option to use the Welch's t-test here. The Mann-Whitney U test is used as alternative. It tests whether one variable tends to have values higher than the other in case of two independent samples (Hart, 2001). The p-value is 0,3379 so the null hypothesis "the two samples are drawn from the same distribution" cannot be rejected. Therefore, we cannot conclude that the treatment has had an effect on the SpO2.

	After minus before		
	Shapiro-Wilk test "Control"	Shapiro-Wilk test "GOT"	Mann-Whitney U test
SpO2	p=0,9410	p=0,0403	**p=0,3379**

Table 2. Overview of the p-values for SpO2 with α=0,05

4 Discussion

The objective of this study, carried out in the context of a thesis, is to investigate in a medical setting whether a paramedical treatment can have an affect on the human physiology, specifically on the oxygen saturation. In the past, research has already been conducted on the influences of mobilizations on the oxygenation (Needham et al., 2009). Within the osteopathy, the effects of GOT have been minimally studied. To the best of our knowledge, this present study is the first one combining GOT with the oxygen saturation. The values of the oxygenation (SpO2 and SaO2) are obtained by two different measuring methods: pulse oximetry and blood gas analyses. These values are measured at several times among twenty participants in critical care.

Measuring the SpO2 with pulse oximetry is a reliable guideline, but the values can be influenced by many factors (Demin et al., 2019). These factors have been avoided as much as possible by strict criteria. Blood gas analyses stay the gold standard (Ebmeier et al., 2018). The twenty treatments have been spread over two months, which means that several nurses performed the blood gas analyses. It has been impossible to do the investigation with one permanent nurse. The supervising doctor has been one permanent person during the whole research. The strict in- and exclusion criteria applied in this study have been necessary to guarantee patient safety. Fontela et al. (2018) emphasize the importance of early mobilization when immobile, even when the patient is very weak. As students there has not been a way to take that risk on ICU, hence the criteria. Two final-year students of osteopathy, then in education at the IAO (Ghent), have performed the interventions on the patients. It is important to make note of this. It was impossible to appoint diplomated osteopaths (D.O.), because of no budget. In further research, budget is needed to avoid this situation. During each treatment given, the same doctor was nearby to supervise. There is tried to repeat the research this year, but the ethics committee of AZ Zeno has not given their permission because of the drastic measures due to the corona crisis (COVID-19).

The several outcomes of oxygenation are compared to each other in the results. From the results, the p-value of sO2 (before minus after) has been

noticed compared to the other p-values. It suggests that the sO2 changes after a GOT, but with a value of 0.0661 the outcome was not statistically significant. From the results of SpO2, it was impossible to draw conclusions. The results are not in line with the expectations. With this present study, we cannot conclude that GOT has an effect on the oxygenation. This requires larger research with a bigger sample size to determine a more reliable p-value and money available to work with D.O.'s. The sample size of this pilot study has been small (N=20); this is increasing the chance of making measurement errors (Faber & Fonseca, 2014). It is possible the null hypothesis has been failed to reject unnecessary. In the research of Manzotti et al. (2020) 69 people have participated. They have performed another soft osteopathic technique as intervention, but have also measured the influence on the SpO2. With a bigger sample size the differences have been statistically significant and a positive result on the SpO2 have been obtained. Also the investigation of Genc et al. (2014) has shown changes in the SpO2 after applying PLE. In this case have participated 120 mechanically ventilated critically ill patients. This suggests that bigger sample sizes do matter.

In the present study, GOT is used as intervention. The GOT techniques performed here have been based on the syllabus of the IAO, written by Peeters and Lason (2014). Within their GOT techniques, the focus is lying on only three parameters: routine, rhythm and rotation. But as mentioned above shows other literature more parameters that are at least equally important (Fieuw et al., 2002; Parsons & Marcer, 2005). In the future, broader focus is needed and the other parameters need to be involved. Therefore, differences in GOT techniques between different school educations can arise.

This present study has only focused on SpO2 and SaO2 as physiological parameters. However, there are more parameters that could affect the physiology by performing a GOT, because the primary aim of a GOT is to recover the physiology (Parsons & Marcer, 2005). If the study has had a broader focus, the obtaining results maybe would have been different. We cannot make statements about the effect of GOT on the total physiology of the human body with only these measured results. Cruz-Montecinos et al. (2017) have shown that manual therapy performed on the thorax and diaphragm immediately affects the long function. It may be interesting to combine GOT in the future with breathings to improve the impact on the physiology. Tucker (2006) emphasizes the

importance of repeating manual treatments. In this research there is only treated once, but it is possible that treating more than once shows other results. Possibly the duration of treatment has an impact too. We have been limited in time per patient, but the duration in other literature seems quite similar (Manzotti et al., 2020; Comhaire et al., 2015; Shi et al., 2011).

This pilot study is a start that hungers for more. Further research requires a bigger sample size to perceive more reliable significant differences. The vital parameters of the human body can be investigated in larger perspective than only focussing on the oxygenation. This would emphasize even more the primary aim of GOT, restore the physiology.

5 Conclusion

To the best of our knowledge, this thesis has been the first research investigating GOT performed on the upper limb combined with the oxygenation of the human body. The obtained results for the oxygenation by the pulse oximeter and the blood gas analyses are difficult to interpret because of the small sample size. It is impossible to draw conclusions whether a GOT affects these tested parameters. We only can conclude that further research is needed. In a follow-up study, it is important to pay attention to the sample size, and to measure and analyse more different physiological parameters to see changes in the physiology. With this pilot study we only have given the starting signal for this topic. However, a holistic way of working stays essential within all disciplines.

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7 Annexes

7.1 Approval of the Ethics Committee

Aan wie het aanbelangd

Per e-mail aan Nan Devos

uw bericht van	uw kenmerk	ons kenmerk	Knokke-Heist
		2015 08	15/12/2015

Geachte heer, mevrouw,

Het uitvoeren door Nan Devos en Carlo Leemans van het bachelorproefonderzoek met titel "The increasing effect of General Osteopathic Treatment in the long-term on the oxygenation of the upper limb performed on ICU patients" werd goedgekeurd door het Ethisch Comité van AZ ZENO tijdens haar vergadering van 14 september 2015.

Deze goedkeuring beperkt zich tot de bekwaamheid van de onderzoeker, de geschiktheid van de faciliteiten en het toestemmingsformulier (punten 4°, 6° en 7° van § 4 van artikel 11 van de wet dd. 07/05/2004 inzake experimenten op de menselijke persoon).

Hoogachtend,

Dhr. L. Vandenberghe
Voorzitter Ethisch Comité

7.2 Informed consent

THE INTERNATIONAL ACADEMY OF OSTEOPATHY

The effect of a General Osteopathic Treatment on the oxygenation of the upper limb performed on the Intensive Care Unit (ICU)

Author: Nan Devos and Carlo Leemans

Promoter: Patrick Rodrigues
External promoter: Bart Devos

Scientific article to obtain the "DO Diploma in Osteopathy" and "Bachelor of Science with Honours in the Osteopathic Medicine"

Academic year: 2015-2016

Informed Consent form for the Intensive Care Unit mentally competent patients, who we are inviting to participate in research on oxygenation after osteopathic treatment.

This Informed Consent Form has two parts:

- Information Sheet (to share information about the research with you)
- Certificate of Consent (for signatures if you agree to take part)

You will be given a copy of the full Informed Consent Form

PART I: The Information Sheet

Introduction:
Dear Sir or Madam,

We are Nan Devos and Carlo Leemans, students at the International Academy of Osteopathy (IAO). We are doing research on the effect of a General Osteopathic Treatment (GOT) on the oxygenation of the upper limb of the human body. GOT is an osteopathic mobilization technique that is used to restore the physiology. We are going to give you information and invite you to be part of this research. You do not have to decide today whether or not you will participate in the research. Before you decide, you can talk to anyone you feel comfortable with about the research.

There may be some words that you do not understand. Please ask us to stop as we go through the information and we will take time to explain. If you have questions later, you can ask them to the doctor, the nurses or us.

Purpose of the research:
The red blood cells in the blood of our arteries contain haemoglobin. Haemoglobin takes care of the transport of oxygen to the tissues. The arterial oxygen saturation is a way measuring the amount of oxygen bound to the haemoglobin in the red blood cells. It measures the ratio between the saturated haemoglobin and the total saturated and unsaturated haemoglobin. For the human body, it is important to have an optimal level of oxygen in your blood. A normal quantity of oxygen saturation in a healthy human being is between 95 and 100%. In the osteopathy, we use mobilization techniques to stimulate the blood flow. The reason we are doing this research is to find out if these osteopathic mobilizations really stimulate the blood flow, and in this way the oxygenation too.

Type of research intervention:
The General Osteopathic Treatment (GOT) we will do is made up five mobilization techniques, as the upper limb consists of multiple joints. These techniques pass fluently into each other.

Participant Selection:
We are inviting mentally competent patients in Intensive Care at the hospital AZ Zeno (campus Knokke) to participate the research, because Intensive Care patients often have low oxygen levels.

Voluntary Participation:
Your participation in this research is entirely voluntary. It is your choice whether to participate or not. Whether you choose to participate or not, all the services you receive at this hospital will continue and nothing will change. You may change your mind later and stop participating even if you agreed earlier.

Procedures and Protocol:
During the osteopathic treatment you will always be located in the Intensive Care.

Because we do not know if the oxygenation will increase after mobilization, we need to compare the measurements with another group of Intensive Care Patients. To do this, we will divide people taking part in this research into two groups. The groups are selected by chance, as if by tossing a coin.

Participants in one group will be given the General Osteopathic Treatment (GOT) on the upper limb while participants in the other group will be given a myofascial mobilization technique. It is important that you do not know which of the two treatments you are given. This information will be in our files. We will compare the two results.

During the study, we will be under supervision of Doctor Bart Devos and nurses of the Intensive care ward. If there is anything you are concerned about or that is bothering you about the research please talk to one of us, the Doctor or one of the nurses.

The myofascial mobilization technique is as placebo. Sometimes when we want to know whether an osteopathic treatment is working, we give some people the pretend. For the research to be good, it is significant that you do not know which of the two treatments you have been given.

Description of the Process:
During the research you will stay in the Intensive Care.

- In the first step, a small amount of blood, equal to about eight to ten CC, will be taken from your arm with the help of the arterial catheter that is placed at the beginning of your stay. Important to know is that blood samples are frequently taken during your stay in Intensive Care to control for example the oxygen saturation. This blood sample will show us different parameters (tHb, sO2 and pO2). We will also measure your oxygen saturation with a pulse oximeter. This is a sensor device placed on the fingertip. It is connected to the monitor, so it brings up a continuous series of results. We will also ask you a few questions about your general health and ask your age and how much you weigh.

- In the next step, which is directly after, we will do the General Osteopathic Treatment (GOT) on your upper limb. The mobilization takes around the fifteen minutes.
- In the third step, which is immediately after the mobilization, we will measure the values again.
- After one hour, the nurse will take a last blood sample.

Duration:
During the research, you will reside in the Intensive Care, so it is not necessary to move you. In total, the research will take half an hour of your time. After that, the research will be finished.

Side Effects and Risks:
The General Osteopathic Treatment (GOT) on the shoulder does not hurt and has no side effects. With the osteopathic mobilization technique we want to encourage the health of the patient. We want to stimulate an optimal blood flow.
This research contains no risks.

Benefits:
There may not be any benefit for you, but your participation is likely to help us find the answer to the research question. The future generations of patients are likely to benefit.

Reimbursements:
There will not be given money or gifts to take part in this research. But we will be very thankful for your cooperation.

Confidentiality:
With this research, something out of the ordinary is being done in your community. It is possible that if others in the community are aware that you are participating, they may ask you questions. We will not be sharing the identity of those participating in the research.

The information that we collect from this research study will be kept confidential. Information about you that will be collected will be put away and no one but the researchers will be able to see it. Any information about you will have a number on it instead of your name. It will not be shared with or given to anyone except Nan Devos, Carlo Leemans, Patrick Rodrigues (promotor), Bart Devos (Doctor and extern promotor), Inge Roman (our attending) and the nurses in Intensive Care.

Sharing the Results:
The knowledge that we get from doing this research will be shared with you through community meetings before it is made widely available to the public. Confidential information will not be shared. There will be small meetings in the community and these

will be announced. After these meetings, we will publish the results in order that other interested people may learn from our research.

Right to Refuse or Withdraw:
You do not have to take part in this research if you do not wish to do so. You may also stop participating in the research at any time you choose. It is your choice and all of your rights will still be respected.

Who to Contact:
If you have any questions you may ask them now or later, even after the study has started. If you wish to ask questions later, you may contact any of the following:

Nan Devos: nan_devos@hotmail.com
0479/49.91.72

Carlo Leemans: carlo.leemans@hotmail.com
0479/77.08.83

PART II: Certificate of Consent

Research on the effect of an osteopathic mobilization technique, named General Osteopathic Treatment (GOT), on the oxygenation of the upper limb in Intensive Care Unit (ICU) patients.

I have read the foregoing information, or it has been read to me. I understand the information. I have had enough time to think about my participation. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this research. I know my participation is completely voluntary and I can withdraw my consent at any time without giving any reason. I give permission that the competent persons, the members of the medical ethics committee and competent authorities may have access to my medical details and research data.

Print Name of Participant _____

Signature of Participant_____

Date_____
(Day/month/year)

If illiterate
I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness_____ Thumbprint of participant:

Signature of witness_____

Date_____
(Day/month/year)

Statement by the researcher/person taking consent
I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands that the following will be done:
-Measuring the oxygen saturation levels
-General Osteopathic Treatment (GOT)
I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of the information sheet and this signed Certificate of Consent has been provided to the participant.

Print Name of Researcher/person taking the consent_____

Signature of Researcher/person taking the consent_____

Date_____
(Day/month/year)

7.3 Statistical tests for the data of the blood gas analysis system

7.3.1 tHb after minus before

Summary statistics

Variable	After_Before_tHb After_Before tHb
Filter	Treatment="Control" Control

Sample size	10
Lowest value	-0,7000
Highest value	1,6000
Arithmetic mean	0,5600
95% CI for the mean	0,04283 to 1,0772
Median	0,5000
95% CI for the median	-0,1000 to 1,2000
Variance	0,5227
Standard deviation	0,7230
Relative standard deviation	1,2910 (129,10%)
Standard error of the mean	0,2286
Coefficient of Skewness	-0,2856 (P=0,6672)
Coefficient of Kurtosis	-0,7507 (P=0,6309)
Shapiro-Wilk test for Normal distribution	W=0,9553 accept Normality (P=0,7311)

Percentiles		95% Confidence interval
2,5		
5	-0,7000	
10	-0,4000	
25	-0,1000	
75	1,2000	
90	1,4000	
95	1,6000	
97,5		

Summary statistics

Variable	After_Before_tHb After_Before tHb
Filter	Treatment="GOT" GOT

Sample size	10
Lowest value	-1,5000
Highest value	1,7000
Arithmetic mean	0,4300
95% CI for the mean	-0,1492 to 1,0092
Median	0,5000
95% CI for the median	0,2000 to 0,8525
Variance	0,6557
Standard deviation	0,8097
Relative standard deviation	1,8831 (188,31%)
Standard error of the mean	0,2561
Coefficient of Skewness	-1,3060 (P=0,0588)
Coefficient of Kurtosis	4,0655 (P=0,0254)
Shapiro-Wilk test for Normal distribution	W=0,8533 accept Normality (P=0,0635)

Percentiles		95% Confidence interval
2,5		
5	-1,5000	
10	-0,6500	
25	0,2000	
75	0,8000	
90	1,3000	
95	1,7000	
97,5		

Independent samples t-test

Sample 1	
Variable	After_Before_tHb After_Before tHb
Filter	Treatment="Control" Control
Sample 2	
Variable	After_Before_tHb After_Before tHb
Filter	Treatment="GOT" GOT

	Sample 1	Sample 2
Sample size	10	10
Arithmetic mean	0,5600	0,4300
95% CI for the mean	0,04283 to 1,0772	-0,1492 to 1,0092
Variance	0,5227	0,6557
Standard deviation	0,7230	0,8097
Standard error of the mean	0,2286	0,2561
F-test for equal variances		P = 0,741

Welch's t-test (assuming unequal variances)

Difference	-0,1300
Standard Error	0,3433
95% CI of difference	-0,8512 to 0,5912
Test statistic t(d)	-0,379
Degrees of Freedom (DF)	17,8
Two-tailed probability	P = 0,7093

7.3.2 tHb 1h after minus before

Summary statistics

Variable	1h_After_before_tHb 1h After-before tHb
Filter	Treatment="Control" Control

Sample size	10
Lowest value	-0,8000
Highest value	2,1000
Arithmetic mean	0,6000
95% CI for the mean	-0,1822 to 1,3822
Median	0,6000
95% CI for the median	-0,6050 to 1,8525
Variance	1,1956
Standard deviation	1,0934
Relative standard deviation	1,8224 (182,24%)
Standard error of the mean	0,3458
Coefficient of Skewness	0,09881 (P=0,8815)
Coefficient of Kurtosis	-1,5540 (P=0,1426)
Shapiro-Wilk test for Normal distribution	W=0,9130 accept Normality (P=0,3026)

Percentiles		95% Confidence interval
2,5		
5	-0,8000	
10	-0,7500	
25	-0,5000	
75	1,8000	
90	2,0000	
95	2,1000	
97,5		

Summary statistics

Variable	1h_After_before_tHb 1h After-before tHb
Filter	Treatment="GOT" GOT

Sample size	10
Lowest value	-1,0000
Highest value	1,9000
Arithmetic mean	0,2100
95% CI for the mean	-0,5057 to 0,9257
Median	-0,05000
95% CI for the median	-0,6525 to 1,3575
Variance	1,0010
Standard deviation	1,0005
Relative standard deviation	4,7643 (476,43%)
Standard error of the mean	0,3164
Coefficient of Skewness	0,6366 (P=0,3418)
Coefficient of Kurtosis	-1,0036 (P=0,4501)
Shapiro-Wilk test for Normal distribution	W=0,9151 accept Normality (P=0,3182)

Percentiles		95% Confidence interval
2,5		
5	-1,0000	
10	-0,8500	
25	-0,6000	
75	1,2000	
90	1,7000	
95	1,9000	
97,5		

Independent samples t-test

Sample 1	
Variable	1h_After_before_tHb 1h After-before tHb
Filter	Treatment="Control" Control
Sample 2	
Variable	1h_After_before_tHb 1h After-before tHb
Filter	Treatment="GOT" GOT

	Sample 1	Sample 2
Sample size	10	10
Arithmetic mean	0,6000	0,2100
95% CI for the mean	-0,1822 to 1,3822	-0,5057 to 0,9257
Variance	1,1956	1,0010
Standard deviation	1,0934	1,0005
Standard error of the mean	0,3458	0,3164
F-test for equal variances		P = 0,796

Welch's t-test (assuming unequal variances)

Difference	-0,3900
Standard Error	0,4687
95% CI of difference	-1,3746 to 0,5946
Test statistic t(d)	-0,832
Degrees of Freedom (DF)	17,9
Two-tailed probability	P = 0,4162

7.3.3 sO2 after minus before

Summary statistics

Variable	After_Before_sO2 After_Before sO2
Filter	Treatment="Control" Control

Sample size	10
Lowest value	-1,5000
Highest value	0,5000
Arithmetic mean	-0,3200
95% CI for the mean	-0,7990 to 0,1590
Median	-0,3000
95% CI for the median	-0,9100 to 0,3575
Variance	0,4484
Standard deviation	0,6697
Relative standard deviation	-2,0927 (-209,27%)
Standard error of the mean	0,2118
Coefficient of Skewness	-0,4050 (P=0,5428)
Coefficient of Kurtosis	-0,7094 (P=0,6613)
Shapiro-Wilk test for Normal distribution	W=0,9525 accept Normality (P=0,6979)

Percentiles		95% Confidence interval
2,5		
5	-1,5000	
10	-1,3000	
25	-0,7000	
75	0,2000	
90	0,5000	
95	0,5000	
97,5		

Summary statistics

Variable	After_Before_sO2 After_Before sO2
Filter	Treatment="GOT" GOT

Sample size	10
Lowest value	-3,1000
Highest value	1,3000
Arithmetic mean	-1,3300
95% CI for the mean	-2,3634 to -0,2966
Median	-1,7500
95% CI for the median	-2,5575 to 0,1300
Variance	2,0868
Standard deviation	1,4446
Relative standard deviation	-1,0861 (-108,61%)
Standard error of the mean	0,4568
Coefficient of Skewness	0,7968 (P=0,2369)
Coefficient of Kurtosis	-0,3165 (P=0,9476)
Shapiro-Wilk test for Normal distribution	W=0,9271 accept Normality (P=0,4195)

Percentiles		95% Confidence interval
2,5		
5	-3,1000	
10	-2,9000	
25	-2,4000	
75	-0,5000	
90	1,0000	
95	1,3000	
97,5		

Independent samples t-test

Sample 1	
Variable	After_Before_sO2 After_Before sO2
Filter	Treatment="Control" Control
Sample 2	
Variable	After_Before_sO2 After_Before sO2
Filter	Treatment="GOT" GOT

	Sample 1	Sample 2
Sample size	10	10
Arithmetic mean	-0,3200	-1,3300
95% CI for the mean	-0,7990 to 0,1590	-2,3634 to -0,2966
Variance	0,4484	2,0868
Standard deviation	0,6697	1,4446
Standard error of the mean	0,2118	0,4568
F-test for equal variances		P = 0,032

Welch's t-test (assuming unequal variances)

Difference	-1,0100
Standard Error	0,5035
95% CI of difference	-2,0978 to 0,07777
Test statistic t(d)	-2,006
Degrees of Freedom (DF)	12,7
Two-tailed probability	P = 0,0661

7.3.4 sO2 1h after minus before

Summary statistics

Variable	1h_after_before_sO2 1h after-before sO2
Filter	Treatment="Control" Control

Sample size	10
Lowest value	-1,1000
Highest value	1,2000
Arithmetic mean	-0,1100
95% CI for the mean	-0,6405 to 0,4205
Median	-0,2000
95% CI for the median	-0,7575 to 0,6575
Variance	0,5499
Standard deviation	0,7415
Relative standard deviation	-6,7413 (-674,13%)
Standard error of the mean	0,2345
Coefficient of Skewness	0,5387 (P=0,4198)
Coefficient of Kurtosis	-0,5850 (P=0,7532)
Shapiro-Wilk test for Normal distribution	W=0,9530 accept Normality (P=0,7039)

Percentiles		95% Confidence interval
2,5		
5	-1,1000	
10	-1,0000	
25	-0,6000	
75	0,5000	
90	1,0000	
95	1,2000	
97,5		

Summary statistics

Variable	1h_after_before_sO2 1h after-before sO2
Filter	Treatment="GOT" GOT

Sample size	10
Lowest value	-2,4000
Highest value	1,3000
Arithmetic mean	0,1400
95% CI for the mean	-0,7039 to 0,9839
Median	0,6500
95% CI for the median	-0,7625 to 1,1050
Variance	1,3916
Standard deviation	1,1796
Relative standard deviation	8,4260 (842,60%)
Standard error of the mean	0,3730
Coefficient of Skewness	-1,2072 (P=0,0790)
Coefficient of Kurtosis	1,0111 (P=0,3694)
Shapiro-Wilk test for Normal distribution	W=0,8733 accept Normality (P=0,1091)

Percentiles		95% Confidence interval
2,5		
5	-2,4000	
10	-1,7000	
25	-0,5000	
75	1,0000	
90	1,2500	
95	1,3000	
97,5		

Independent samples t-test

Sample 1	
Variable	1h_after_before_sO2 1h after-before sO2
Filter	Treatment="Control" Control
Sample 2	
Variable	1h_after_before_sO2 1h after-before sO2
Filter	Treatment="GOT" GOT

	Sample 1	Sample 2
Sample size	10	10
Arithmetic mean	-0,1100	0,1400
95% CI for the mean	-0,6405 to 0,4205	-0,7039 to 0,9839
Variance	0,5499	1,3916
Standard deviation	0,7415	1,1796
Standard error of the mean	0,2345	0,3730
F-test for equal variances		P = 0,183

Welch-test (assuming unequal variances)

Difference	0,2500
Standard Error	0,4406
95% CI of difference	-0,6892 to 1,1892
Test statistic t(d)	0,567
Degrees of Freedom (DF)	15,2
Two-tailed probability	P = 0,5788

7.3.5 pO2 after minus before

Summary statistics

Variable	After_Before_pO2 After_Before pO2
Filter	Treatment="Control" Control

Sample size	10
Lowest value	-21,0000
Highest value	16,5000
Arithmetic mean	-3,0900
95% CI for the mean	-10,9296 to 4,7496
Median	-5,5000
95% CI for the median	-9,7200 to 7,4525
Variance	120,1010
Standard deviation	10,9591
Relative standard deviation	-3,5466 (-354,66%)
Standard error of the mean	3,4656
Coefficient of Skewness	0,3582 (P=0,5900)
Coefficient of Kurtosis	-0,02373 (P=0,8565)
Shapiro-Wilk test for Normal distribution	W=0,9546 accept Normality (P=0,7228)

Percentiles		95% Confidence interval
2,5		
5	-21,0000	
10	-15,5500	
25	-9,3000	
75	5,3000	
90	12,9500	
95	16,5000	
97,5		

Summary statistics

Variable	After_Before_pO2 After_Before pO2
Filter	Treatment="GOT" GOT

Sample size	10
Lowest value	-27,4000
Highest value	13,8000
Arithmetic mean	-4,3600
95% CI for the mean	-14,7331 to 6,0131
Median	-1,4500
95% CI for the median	-20,7101 to 9,1751
Variance	210,2671
Standard deviation	14,5006
Relative standard deviation	-3,3258 (-332,58%)
Standard error of the mean	4,5855
Coefficient of Skewness	-0,4585 (P=0,4914)
Coefficient of Kurtosis	-0,9992 (P=0,4532)
Shapiro-Wilk test for Normal distribution	W=0,9337 accept Normality (P=0,4852)

Percentiles		95% Confidence interval
2,5		
5	-27,4000	
10	-26,0500	
25	-16,3000	
75	5,5000	
90	13,1500	
95	13,8000	
97,5		

Independent samples t-test

Sample 1	
Variable	After_Before_pO2 After_Before pO2
Filter	Treatment="Control" Control
Sample 2	
Variable	After_Before_pO2 After_Before pO2
Filter	Treatment="GOT" GOT

	Sample 1	Sample 2
Sample size	10	10
Arithmetic mean	-3,0900	-4,3600
95% CI for the mean	-10,9296 to 4,7496	-14,7331 to 6,0131
Variance	120,1010	210,2671
Standard deviation	10,9591	14,5006
Standard error of the mean	3,4656	4,5855
F-test for equal variances		P = 0,417

Welch's t-test (assuming unequal variances)

Difference	-1,2700
Standard Error	5,7478
95% CI of difference	-13,3967 to 10,8567
Test statistic t(d)	-0,221
Degrees of Freedom (DF)	16,8
Two-tailed probability	P = 0,8278

7.3.6 pO2 1h after minus before

Summary statistics

Variable	1h_after_before_pO2 1h_after_before pO2
Filter	Treatment="Control" Control

Sample size	10
Lowest value	-21,2000
Highest value	12,2000
Arithmetic mean	-1,2500
95% CI for the mean	-9,0744 to 6,5744
Median	0,7000
95% CI for the median	-11,3801 to 7,5675
Variance	119,6339
Standard deviation	10,9377
Relative standard deviation	-8,7502 (-875,02%)
Standard error of the mean	3,4588
Coefficient of Skewness	-0,9773 (P=0,1501)
Coefficient of Kurtosis	0,1533 (P=0,7496)
Shapiro-Wilk test for Normal distribution	W=0,8883 accept Normality (P=0,1623)

Percentiles		95% Confidence interval
2,5		
5	-21,2000	
10	-19,9000	
25	-3,4000	
75	7,2000	
90	10,0500	
95	12,2000	
97,5		

Summary statistics

Variable	1h_after_before_pO2 1h_after_before pO2
Filter	Treatment="GOT" GOT

Sample size	10
Lowest value	-15,6000
Highest value	9,8000
Arithmetic mean	-3,0700
95% CI for the mean	-8,4127 to 2,2727
Median	-2,6000
95% CI for the median	-9,8700 to 2,4000
Variance	55,7801
Standard deviation	7,4686
Relative standard deviation	-2,4328 (-243,28%)
Standard error of the mean	2,3618
Coefficient of Skewness	-0,05065 (P=0,9391)
Coefficient of Kurtosis	-0,1733 (P=0,9539)
Shapiro-Wilk test for Normal distribution	W=0,9832 accept Normality (P=0,9799)

Percentiles		95% Confidence interval
2,5		
5	-15,6000	
10	-13,4000	
25	-8,4000	
75	2,4000	
90	6,1000	
95	9,8000	
97,5		

Independent samples t-test

Sample 1	
Variable	1h_after_before_pO2 1h_after_before pO2
Filter	Treatment="Control" Control
Sample 2	
Variable	1h_after_before_pO2 1h_after_before pO2
Filter	Treatment="GOT" GOT

	Sample 1	Sample 2
Sample size	10	10
Arithmetic mean	-1,2500	-3,0700
95% CI for the mean	-9,0744 to 6,5744	-8,4127 to 2,2727
Variance	119,6339	55,7801
Standard deviation	10,9377	7,4686
Standard error of the mean	3,4588	2,3618
F-test for equal variances		P = 0,271

Welch's t-test (assuming unequal variances)

Difference	-1,8200
Standard Error	4,1882
95% CI of difference	-10,6987 to 7,0587
Test statistic t(d)	-0,435
Degrees of Freedom (DF)	15,9
Two-tailed probability	P = 0,6697

7.4 Statistical tests for the data of the pulse oximeter

7.4.1 POX after-before

Summary statistics

Variable	POX_after_before POX after-before
Filter	Treatment="Control" Control

Sample size	10
Lowest value	-4,0000
Highest value	4,0000
Arithmetic mean	0,1000
95% CI for the mean	-1,6012 to 1,8012
Median	0,5000
95% CI for the median	-2,0000 to 2,0000
Variance	5,6556
Standard deviation	2,3781
Relative standard deviation	23,7814 (2378,14%)
Standard error of the mean	0,7520
Coefficient of Skewness	-0,1475 (P=0,8240)
Coefficient of Kurtosis	-0,3703 (P=0,9095)
Shapiro-Wilk test for Normal distribution	W=0,9761 accept Normality (P=0,9410)

Percentiles		95% Confidence interval
2,5		
5	-4,0000	
10	-3,0000	
25	-2,0000	
75	2,0000	
90	3,0000	
95	4,0000	
97,5		

Summary statistics

Variable	POX_after_before POX after-before
Filter	Treatment="GOT" GOT

Sample size	10
Lowest value	-2,0000
Highest value	3,0000
Arithmetic mean	0,9000
95% CI for the mean	-0,3367 to 2,1367
Median	2,0000
95% CI for the median	-1,0000 to 2,0000
Variance	2,9889
Standard deviation	1,7288
Relative standard deviation	1,9209 (192,09%)
Standard error of the mean	0,5467
Coefficient of Skewness	-0,6161 (P=0,3573)
Coefficient of Kurtosis	-1,3045 (P=0,2619)
Shapiro-Wilk test for Normal distribution	W=0,8367 reject Normality (P=0,0403)

Percentiles		95% Confidence interval
2,5		
5	-2,0000	
10	-1,5000	
25	-1,0000	
75	2,0000	
90	2,5000	
95	3,0000	
97,5		

Mann-Whitney U test (independent samples)

Sample 1	
Variable	POX_after_before POX after-before
Filter	Treatment="Control" Control
Sample 2	
Variable	POX_after_before POX after-before
Filter	Treatment="GOT" GOT

	Sample 1	Sample 2
Sample size	10	10
Lowest value	-4,0000	-2,0000
Highest value	4,0000	3,0000
Median	0,5000	2,0000
95% CI for the median	-2,0000 to 2,0000	-1,0000 to 2,0000
Interquartile range	-2,0000 to 2,0000	-1,0000 to 2,0000

Mann-Whitney U test (independent samples)

Average rank of first group	9,2500
Average rank of second group	11,7500
Mann-Whitney U	37,50
Test statistic Z (corrected for ties)	0,958
Two-tailed probability	P = 0,3379

7.5 Table of results

Patients	Treatment	Gender
1	GOT	Female
2	GOT	Female
3	GOT	Female
4	GOT	Female
5	GOT	Female
6	GOT	Male
7	GOT	Male
8	GOT	Male
9	GOT	Male
10	GOT	Male
11	Control	Female
12	Control	Female
13	Control	Female
14	Control	Female
15	Control	Female
16	Control	Male
17	Control	Male
18	Control	Male
19	Control	Male
20	Control	Male

7.5.1 tHb

tHb before	tHb after	tHb after minus before	tHb 1h after	tHb 1h after minus before
11,2	11,4	0,2	10,6	-0,6
9,9	10,1	0,2	9,7	-0,2
12,5	13	0,5	13,7	1,2
10,8	11,3	0,5	10,9	0,1
9,7	10,6	0,9	9	-0,7
12,9	13,6	0,7	13,2	0,3
11,9	10,4	-1,5	13,8	1,9
14,9	15,2	0,3	14,5	-0,4
9,6	11,3	1,7	11,1	1,5
12,9	13,7	0,8	11,9	-1
9,8	10,2	0,4	9,1	-0,7
12,5	12,4	-0,1	13,4	0,9
10,7	11,9	1,2	10,8	0,1
15,1	15	-0,1	14,6	-0,5
10,6	9,9	-0,7	12,7	2,1
14,8	15,2	0,4	15,7	0,9
12,1	13,7	1,6	11,3	-0,8
11,4	12	0,6	13,2	1,8
9,3	10,4	1,1	9,6	0,3
12,7	13,9	1,2	14,6	1,9

7.5.2 sO2

sO2 before	sO2 after	sO2 after minus before	sO2 1h after	sO2 1h after minus before
97,2	95,3	-1,9	97,8	0,6
97,8	96,7	-1,1	98,6	0,8
96,4	97,1	0,7	97,1	0,7
97,9	94,8	-3,1	99,2	1,3
99,6	97,2	-2,4	98,6	-1
95,8	95,3	-0,5	96,8	1
97,2	95,6	-1,6	96,7	-0,5
98,1	96,1	-2	97,8	-0,3
96,9	98,2	1,3	98,1	1,2
97,3	94,6	-2,7	94,9	-2,4
98,6	97,9	-0,7	97,7	-0,9
97	97,1	0,1	97,8	0,8
96,5	96,3	-0,2	95,4	-1,1
97,6	98,1	0,5	97,5	-0,1
98,2	97,8	-0,4	98,1	-0,1
97,5	96,4	-1,1	97,2	-0,3
94,7	95,2	0,5	95,9	1,2
98,1	96,6	-1,5	98,6	0,5
96,6	96,8	0,2	96	-0,6
97,8	97,2	-0,6	97,3	-0,5

7.5.3 pO2

pO2 before	pO2 after	pO2 after minus before	pO2 1h after	pO2 1h after minus before
94,8	74,9	-3	92,1	-2,7
112,4	88,4	13,8	106,5	-5,9
89,5	85,4	-7,6	90,5	1
102,7	77,8	3,5	87,1	-15,6
73,9	81,6	-24,7	83,7	9,8
69,4	72,3	-27,4	66,9	-2,5
109,2	83,1	12,5	111,6	2,4
97,9	74,7	0,1	86,7	-11,2
103,6	86,6	5,5	95,2	-8,4
78,6	72,5	-16,3	81	2,4
89,2	86,5	-8,5	87,6	-1,6
95,3	96,7	-2,5	102,5	7,2
100,7	93,3	5,3	104,3	3,6
87,4	86,1	-10,1	86,4	-1
114,6	101,5	16,5	96	-18,6
88,5	94,7	-8,7	96,4	7,9
74,9	76,8	-21	87,1	12,2
89,3	90,9	-9,3	91,7	2,4
94	76,5	-2	72,8	-21,2
106,7	79,2	9,4	103,3	-3,4

7.5.4 POX

POX before	POX after	POX after minus before
98	100	2
97	96	-1
98	98	0
96	98	2
95	97	2
99	98	-1
98	100	2
100	98	-2
94	96	2
97	100	3
97	97	0
95	99	4
98	100	2
99	98	-1
96	97	1
97	98	1
100	96	-4
98	96	-2
100	98	-2
97	99	2