2021-02-24

Saturationsmätning vid 6 minuters gångtest

Sökning utförd i databasen Pubmed med sökorden "pulse oxymeter AND exercise/movement/motion", "6 minute walk test AND saturation", " 6 minute walk test AND pulse oxymeter". Artiklar med publiceringsdatum efter år 2000 inkluderades. Titlar, abstract och artiklar i fulltext lästes och relevanta artiklar valdes ut, se exempel nedan. Observera att detta inte är en komplett litteratursökning/granskning, utan bör ses som en screening av tillgängligt vetenskapligt material. Nedan följer en sammanfattning samt korta utdrag från den genomgångna litteraturen.

Sammanfattning:

- En pulsoxymeter mäter syremättnad i det arteriella blodet via genomlysning av en kroppsdel. På baksidan av mätaren absorberas ljuset av en mottagare. Mätaren räknar bort det ljus som absorberats av det venösa blodet och omkringliggande vävnad så att endast det ljus som absorberats av det pulserande blodet i artärerna mäts och presenteras. En normal saturation ska ligga mellan 95-100% hos en vuxen frisk person.
  En saturation på 90 % i vila samt 80-85 % vid ansträngning ses som de lägsta acceptabla nivåerna hos en vuxen person med Covid-19. Avbryt aktivitet om saturationen sjunker under 80-85 % (nivåerna varierar i litteraturen). I de fall saturationen sjunker under aktivitet, är det viktigt att den återgår till utgångsvärdet inom 2 minuter i vila efter avslutad aktivitet (källa KNGF).

- Potentiella felkällor vid saturationsmätning med pulsoxymeter är bland annat: inkorrekt placering av mätare, nagellack, lösnaglar, kalla extremiteter, nedsatt perifer cirkulation, starkt ljus i rummet, hudfärg, låg perfusionskvot (nedsatt gasutbyte i lungorna), vissa sjukdomar (hjärtinfarkt, lågt blodtryck, myeloisk leukemi etc.), kolmonoxid i blodet (binder till hemoglobinet och ger ett felaktigt högt värde), närhet till utrustning med elektromagnetiska källor eller en datortomograf, samt ofrivilliga/frivilliga rörelser.
  Om patienten rör sig under mätningen kan det bland annat leda till att pulsation i venöst blod eller omkringliggande vävnad tolkas som den rätta signalen, vilket ger ett felaktigt värde. Vid gång ökar också blodflödet i den arbetande muskulaturen och minskar i perifera vävnader så som fingrar. Detta kan göra det svårt för mätaren att uppfatta signalerna, vilket i sin tur kan ge ett felaktigt värde.
  Om flera av dessa felkällor inträffar samtidigt innebär detta ökad risk för felaktigt värde. I vissa fall kan mätaren visa ett falskt högt värde trots att patienten har ett påverkat gasutbyte i lungorna. I den genomgångna litteraturen tycks det dock vara vanligast att mätaren visar ett falskt lågt värde. De pulsoxymetrar som tillverkas idag ska vara utformade så att de klarar av att utföra mätning ändå och till viss del kompensera för dessa felkällor. Mätarna är dock framförallt utformade för mätning före/efter test då patienten är stilla.

- Utifrån genomgången litteratur finns ingen samstämmighet gällande vilken lokalisation (finger, öra, panna) som fungerar bäst vid mätning under rörelse. En del studier hävdar att mätning bör ske centralt (panna), så att mätningen inte påverkas av nedsatt perifer cirkulation. De studier som beskriver utförandet av 6 minuters gångtest använder sig oftast av fingerpulsoximeter. Majoriteten av de genomgångna studierna anger att fingerpulsoximeter inte är tillförlitligt vid mätning under rörelse.

- Utifrån genomgången litteratur finns ingen samstämmighet gällande vilket märke av pulsoxymeter som lämpar sig bäst vid mätning under rörelse. Studier som analyserar mätare

från ett visst företag är specifika för just dessa mätare och kan inte generaliseras till andra mätare som används på samma lokalisation. Om jämförelse av saturationsvärden vid olika tidpunkter/på olika enheter ska ske bör mätningen vara utförd med en pulsoxymeter av samma modell för tillförlitligt resultat. Det är tveksamt om saturationsvärden vid olika tidpunkter/på olika enheter bör jämföras med varandra då det är många faktorer runtom mätningen som kan påverka resultatet. Mätarna bör servas regelbundet och rengöras enligt rutin med rätt typ av ytdesinfektion för den specifika mätaren.

- Saturationsmätning med pulsoxymeter kan ej ge ett lika exakt värde som till exempel analys av artärblodgas. Trots detta är det ett relativt billigt, noninvasivt och lättillgängligt verktyg som kan ge vägledning i kombination observation av kliniska parametrar, samt till exempel skattning enligt Borgs RPE-skala.

Källförteckning

1. KNGF position statement: Recommendations for physiotherapy in patients with Covid-19.
OBS: ej ett resultat av sökningen på Pubmed. Tas med i denna översikt som källa till lägsta acceptabla saturationsnivåer vid vila respektive aktivitet hos patienter med Covid-19. Dessa nivåer varierar något beroende på källa.

It is possible that (serious) exercise-induced oxygen desaturation occurs during a treatment session or when a patient performs home exercises or is physically active in another way. Therefore, it is important that oxygen saturation (SpO2) is monitored to identify potential desaturation. Measure oxygen saturation prior to, during and immediately after exercise training or physical activity, in particular when the patient experiences breathlessness or fatigue. The physiotherapist can provide guidance on the correct use of the pulse oximeter by the patient themselves. Use 90% of SpO2 as lower limit at rest and 85% of SpO2 during exercise or physical activities. Stop physical activities or exercises when desaturation (SpO2 < 85% during exercise) occurs. In case the saturation level decreased, it is important that the saturation level reaches its pre-activity level, measured at rest, within two minutes. Intensive monitoring of oxygen saturation is not indicated when patients have no signs of desaturation in the first two weeks of increasing exercise intensity.

2. Från hemsidan https://www.fysiosupplies.se/nonin-onyx-vantage-9590-red angående den pulsoxymeter som finns på Rörelse och hälsa (Nonin Onyx Vantage 9590 Red)

Även för människor med en låg perfusionskvot (gasutbyte i lungorna) och för patienter som rör sig under mätningen kan denna Nonin Onyx Vantage 9590 ge en tydlig analys av syreinnehållet i blodet (SpO2). Nonin Onyx är det enda märket av fingerpulsoximetrar, där den vetenskapligt beprövade noggrannheten och prestandan bevisats genom publicerade kliniska undersökningar som granskats av experter.

3. Mantha S, Tripuraneni SL, Roizen MF, Fleisher LA. Proposed Modifications in the 6-Minute Walk Test for Potential Application in Patients With Mild COVID-19: A Step to Optimize Triage Guidelines. *Anesth Analg*. 2020;131(2):398-402. doi:10.1213/ANE.0000000000004986

We propose to utilize the 6MWT with the modifications of using continuous finger pulse oximetry for SpO_2 monitoring and wearing a surgical mask in laboratory-confirmed adult patients with uncomplicated or mild illness.

The finger pulse oximeters may not be very accurate when compared to saturation values obtained from blood gas analysis of arterial blood when the entire range from 70% to 100% is considered. However, in the range of saturation values applicable in the present context, that is, 90–100%, the "limits of agreement," is clinically acceptable. Hence, the use of finger pulse oximeters in the potential application of the 6MWT test should not pose a problem.

4. Petterson MT, Begnoche VL, Graybeal JM. The effect of motion on pulse oximetry and its clinical significance. Anesth Analg. 2007 Dec;105(6 Suppl):S78-84.
doi: 10.1213/01.ane.0000278134.47777.a5. PMID: 18048903. Review.

Factors affecting the absorbance characteristics include dyshemoglobins (carboxyhemoglobin and methemoglobin), dark skin pigmentation, nail polish, and dyes. A low signal-to-noise ratio leading to inaccurate readings can be caused by a low pulsatile signal (low perfusion), high noise (bright lights, electromagnetic interference, or motion), or a combination of the two (such as motion occurring during low perfusion). Of all of these factors, motion artifact has been the most clinically troublesome, resulting in loss of data, inaccurate readings, and false alarms. Voluntary and involuntary movement, such as movement during transport, tapping, rubbing, scratching, waving, shivering, and seizures in adult and pediatric patients are some common sources of patient motion in the clinical setting. Motion artifact can either cause the pulse oximeter to interpret motion as the true signal or obscure the true signal with noise, leading to inaccurate readings, false alarms, and most importantly, missed true alarms.

5. Enright PL. The six-minute walk test. Respir Care. 2003 Aug;48(8):783-5. PMID: 12890299. Review.

What variables can be measured in the 6MWT? The primary measurement is the total distance walked. Secondary measures can include fatigue and dyspnea, measured with a modified Borg or visual analog scale. Arterial oxygen saturation can also be measured via pulse oximetry, as long as the oximeter is portable and not heavy. However, I have used 3 different pulse oximeters in large epidemiologic studies during the past 10 years, and I found an unacceptably high failure rate, due to motion artifact. For the last 2 studies I chose fourth-generation pulse oximeters specifically designed to compensate for motion artifact. They are reliable for determining the oxygen saturation before and after the 6MWT test, but, in my opinion you should be very cautious in interpreting oxygen saturation readings obtained during exercise.

6. Chan ED, Chan MM, Chan MM. Pulse oximetry: understanding its basic principles facilitates appreciation of its limitations. Respir Med. 2013 Jun;107(6):789-99. doi: 10.1016/j.rmed.2013.02.004. Epub 2013 Mar 13. PMID: 23490227. Review.

Thus, for continuous monitoring of SpO 2, one particular type of probe may be more appropriate than others depending on the clinical circumstance; i.e. , some “trial-and-error” may be necessary to find the optimal probe. For example, in hypotensive, vasoconstricted patients, ear and forehead probes may be more reliable as these areas are less likely to vasoconstrict than the fingers in response to endogenous and exogenous catecholamines. In hypothermia, where there is secondary vasoconstriction, the forehead probe has been shown to be more reliable than the finger probe.

Excessive movement such as tremor or convulsions has been documented to cause spuriously low SpO 2 , with desaturations below 50% sometimes observed, though less commonly SpO 2 overestimations can also occur. In theory, motion can cause the normally static tissues in relation to the sensor position to change over the time frame of the arterial pulses. At times, this motion can augment or mimic the cardiac-induced signals as the blood in the veins (and other previously stationary tissues) are now moving, further modulating the red and IR light attenuation in the probed tissue. However, many newer generation pulse oximeters have improved processing algorithms that reduce the occurrence of false SpO 2 readings due to excessive patient movements. Inaccurate SpO 2 readings can occur with conditions that decrease arterial blood perfusion. Falsely low SpO 2 can occur with venous pulsations, excessive movement, pigmented dyes, and certain dyshemoglobins. It is important to emphasize that even in the most optimal patient-pulse oximeter interface and settings, a completely normal SpO 2 does not rule out gas exchange problems in the lungs or the adequacy of ventilation since the alveolar-arterial oxygen difference and P aCO 2 are not measured by pulse oximetry.

7. Jubran, A. Pulse oximetry. Crit Care 19, 272 (2015). https://doi.org/10.1186/s13054-015-0984-8. Review.

The response time of conventional oximeter probes varies; ear probes respond quicker to a change in O2 saturation than finger probes. A recent study compared the response time of the conventional finger probe with the reflectance forehead probe in patients undergoing general anesthesia. The lengths of time it took to detect a decrease in SpO2 to 90 % after apnea was induced (desaturation response time) were 94 seconds for the forehead probe and 100 seconds for the finger probe. After mask ventilation was started, the lengths of time it took to detect an increase in SpO2 to 100 % (re-saturation response time) were 23.2 seconds for the forehead probe and 28.9 seconds for the finger probes. The investigators speculated that the shorter response time with the reflectance forehead probe was most likely due to the location of the probe rather than to the workings of the reflectance technology. The forehead probe monitors O2 saturation from the supraorbital artery in which blood flow is abundant and is less likely to be affected by vasoconstriction than is a peripheral artery.

8. Torp KD, Modi P, Simon LV. Pulse Oximetry. 2020 Jul 10. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan–. PMID: 29262014. Bok.

Oxygen saturation levels around 96% to 100% are considered normal at sea level. Normal individuals living at higher elevations may have lower oxygen saturation levels. Pulse oximeters are usually calibrated to a range of saturation from 70% to 100% with an accuracy of 2% to 4%, which means

that pulse oximeter is reading lower than 70%, may not be accurate compared to the gold standard invasive blood gas measurements.

Pulse oximetry relies on light absorption through a tissue bed with pulsating blood. Therefore factors that interfere with those parameters can interfere with the reading of pulse oximeters. One of the common examples of interfering factors is nail polish and artificial fingernails. Pulsating blood is another prerequisite for an accurate reading. The pulse amplitude in tissue beds is very small and accounting for about only 5% of the pulse oximeter signals to be available for analysis. Any further decrement in pulse wave amplitude such as severe hypotension, cold extremities, Raynaud disease or other factors such as excessive motion may interfere with an accurate reading. Pulse oximeter manufacturers are trying to mitigate these factors by different strategies with hardware sensor and software algorithm improvements. Therefore, publications reporting limitations of certain pulse oximeters may be specific to that manufacturer or make and model.

9. Kelly KL, Carlson AR, Allison TG, Johnson BD. A comparison of finger and forehead pulse oximeters in heart failure patients during maximal exercise. Heart Lung. 2020 May-Jun;49(3):259-264. doi: 10.1016/j.hrtlng.2019.10.012. Epub 2019 Nov 14. PMID: 31735457; PMCID: PMC7220844. Clinical trial.

Pulse oximeters, clinically used to measure oxygen saturation (SpO 2), rely on adequate perfusion of the tissues over which they are placed. Heart failure (HF) patients can have impaired peripheral perfusion which may compromise the accuracy of a peripherally placed pulse oximeter. This decrease in peripheral perfusion may be especially apparent during exercise. These observations expand on the current understanding of pulse oximetry function in HF patients or in those with low cardiac output by testing these devices during exercise. Overall, these data suggest that the finger-placed pulse oximeter systematically reports lower oxygen saturation values than the forehead pulse oximeter, and that the finger pulse oximeter is poor at detecting pulse rate during peak exercise. Forehead pulse oximeters may be more reliable compared to finger pulse oximeters in obtaining SpO 2 measurements in HF patients during a treadmill maximal exercise test.

10. Gehring H, Hornberger C, Matz H, Konecny E, Schmucker P. The effects of motion artifact and low perfusion on the performance of a new generation of pulse oximeters in volunteers undergoing hypoxemia. Respir Care. 2002 Jan;47(1):48-60. PMID: 11749687. Clinical trial.

The established model of creating motion artifact and low perfusion is capable of simulating a hierarchy of severe clinical situations. With solely motion or solely reduced perfusion the percentage of errors exceeding +/- 3% of SpO2 increased by 20% and 10%, respectively, compared to the control period. Simultaneous presence of motion and reduced perfusion leads to a relative incidence of > 35% of errors > 3% of SpO2 for the various oximeters. In this situation the N-3000 and the Datex-Ohmeda 3900P exhibited differences between estimated pulse rate and electrocardiographically-measured heart rate > 25 beats/min > 37% of the time.