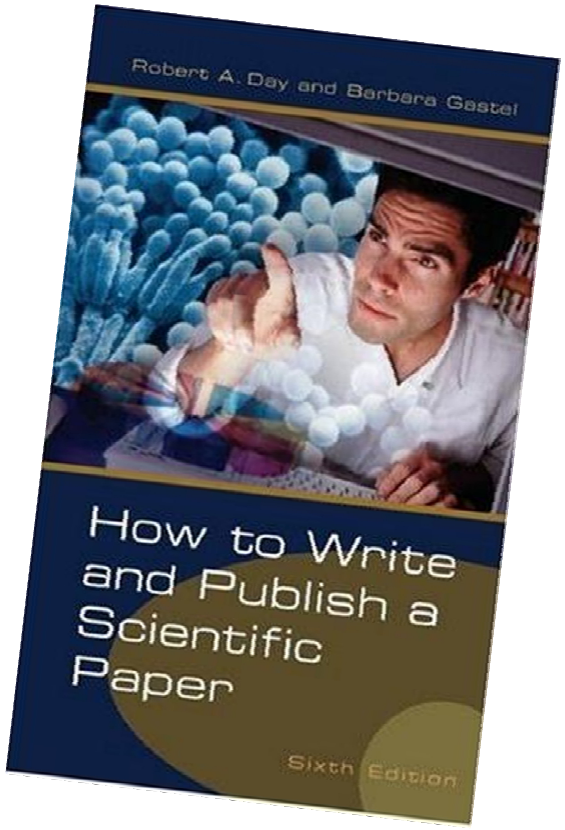
Vitenskapelige artikler



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- Tittel, forfattere, tilhørighet, adresser, kontaktinformasjon
- Abstract
  - Miniversjon av artikkelen. Kort oppsummering av IMRAD
- Keywords
- Introduction
  - Hva/hvorfor. Hva er gjort før? Hvilken metode er brukt? Hovedresultat og – konklusjon.
- Materials and methods
  - Detaljert om hva som er gjort og hvordan. Oppskrift for andre som vil gjenta forsøket.
- Results
  - Resultatene av målingene/forsøkene. Ingen tolkning/synsing.
- Discussion
  - Diskuter resultatene, tolk, signifikante funn?, sammlign med andre artikler, konsekvenser.
- Conclusion
  - Hva er hovedfunnene (kan være del av Discussion)?
- Acknowledgements
  - Takk de som har bidratt men ikke er medforfattere
- References
  - Harvard (2011) / Vancouver [1]

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Electrical Impedance of Stainless Steel Needle Electrodes

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Abstract—We present experimental findings regarding variability and stability of the electrical impedance properties of medical grade stainless steel needle electrodes *in vitro*. Monopolar impedance spectra (1 Hz to 1 MHz) were measured and scanning electron microscope images were obtained for five needle types with active electrode area from 0.28 to 0.7 mm^2. A saline tank (0.9% NaCl) was used as tissue model. Measurements were done before and after electrolytic treatment with anodic and cathodic DC currents of 1 μA. With active electrode areas below 1 mm^2, high influence from electrode polarization impedance (EPI) was expected at low frequencies (LF). For higher frequencies (HF) the EPI decreases and the impedance of the surrounding tissue is more pronounced. The hypothesis tested was that the EPI at LF would depend upon contact area, alloy composition, surface structure, and treatment of the active electrode, and at HF upon the electrode area geometry, and the specific resistivity of saline. Our results show large differences in electrical properties between needle types. After electrolytic treatment the EPI decreased. After 5–48 h of saline exposure the EPI increased, both for treated and untreated needles. Cathodic treatment gave lower impedance and drift than anodic or no treatment.

Keywords—Electrical properties, Medical grade, *In vitro*, EMG-electrodes, Long-term stability, SEM.

INTRODUCTION

In treatment of acute cardiac arrest, physicians need fast vascular access. In an ongoing project aiming at developing better tools for quick and effective vascular access we use medical grade stainless steel (MGSS) needle electrodes to locate the blood vessels based on impedance guided needle positioning.[15] The use of needles and other sub-mm^2 electrodes have long traditions in anesthesia,[23] neurology,[3,4] and cardiology,[24] and miniaturization of electrodes has increasing relevance in development of new applications today.[12,15,22] Clinicians and others using small electrodes for measurement or stimulation in tissue or suspension, have to take great care in using electrodes with proper characteristics. The quality and repeatability of the measurement or treatment is dependent on the electrode properties. Butson[4] concludes: "*Electrode impedance has a substantial effect on the volume of tissue activated and accurate representation of electrode impedance should be an explicit component of computational models of voltage-controlled deep brain stimulation.*" Merrill[20] has also discussed impedance and patient safety during electric stimulations. Important factors that determine the electrode properties are type of material,[21] contact area,[15] roughness factor,[1,13] geometry (Merrill *et al.*;[20] Schwan, p. 286[26]), and surface treatment[3] of the active electrode area. These factors will be the same for electrodes used both for measurements and stimulations, but the experienced impedance of the electrode system will be highly dependent of the excitation signal. For stimulation the excitation signals often are pulses driving the electrode system into non-linear operation. A typical signal can be a square pulse, which typically is monophasic with relatively high amplitude.[20] Such a signal will see a totally different impedance, compared to that measured with small signal (amplitude) sinus excitation.[8,26] In context with our application[15] the present study was limited to small signal responses due to sinus excitation within the linear region.[8,26]

Other investigators[6,8,17] have pointed out that stainless steel alloys can change electrode properties during use. Johnson *et al.*[14] have showed that the impedance of iridium microelectrodes can be reduced to less than the half after electrolytic treatment, Buchthal and Rosenfalck[3] passed current though

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