| Project Details | |
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| Project Code | MRCNMH24Ba Leese |
| Title | Microneedle integrated foetal scalp electrodes for neonatal brain monitoring |
| Research Theme | Neuroscience & Mental Health |
| Summary | Lack of oxygen to a baby during childbirth (peripartum hypoxia) can result in brain damage, cerebral palsy, or even neonatal death, and cannot currently be accurately predicted with gold standard foetal monitoring techniques. In this project, novel foetal scalp electrodes will be developed, integrating amplitude-electroencephalography (aEEG) with microneedle-technologies for accurate brain function assessment and early intervention to reduce hypoxic brain injury. |
| Description | The increasing number of preterm births with risk of long-term neurological consequences determines a growing need for accurate cerebral function monitoring in newborns. Each year data consistently shows that brain injury occurred in 3.4/1000 live births at or soon after the time of birth in the UK alone. Current foetal monitoring techniques involve cardiotocography (CTG) which records changes in the foetal heart rate and their temporal relationship to uterine contractions. Although part of routine practice, CTG is not associated with reduction in cerebral palsy or infant mortality rates or an improvement in other standard measures of neonatal wellbeing. Amplitude-integrated electroencephalography (aEEG) is an established method of monitoring brain function, to inform therapeutic hypothermia or 'cooling'. In this project, novel foetal scalp electrodes will be developed, integrating amplitude-electroencephalography (aEEG) with microneedle-technologies for accurate brain function assessment and early intervention to reduce hypoxic brain injury. Research Question: Can microneedle technologies be integrated with aEEG to transform foetal monitoring techniques? Aims: Microneedles are sub-millimeter (polymeric) needle arrays that are minimally invasive to neonates, penetrating the first few layers of skin and do not interact with pain receptors beneath the skin. The aim is to develop microneedle technologies via additive manufacturing to enable flexible and tailorable designs for novel foetal monitoring electrodes. Recent work from the supervisory team (Leese, Laabei), has shown that we can utilise additive manufacturing to enable microneedle fabrication of different function, whether it be conductivity for detection or hydrogels for drug delivery (Small 2023; Biomaterials Advances, 2023, 213467; Adv. Mater. Technol. 2023). This project aims to optimise conductive microneedles, as hollow (mini-hypodermic needles) or solid microneedles, to enhance the signal from the aEEG and foetal heart monitoring systems developed by members of the supervisory team (Chakkarapani, Dahnoun, Austin). Objective 1: Optimisation and characterisation of microneedle arrays. The student will study the optimal shape and array size of the microneedles and assess the polymeric material properties for suitability as electrodes. The student will steer this objective in two main ways (i) to explore adding further functionality to the microneedles, including therapeutic coatings and (ii) as we hypothesise that the adhesion of the sensors to the foetal scalp will be challenging, different conductive elastomers as possible microneedle electrode materials will be |

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| | investigated. Objective 2: Integrating the microneedles with the aEEG electrodes. In this project, the student will focus on developing and optimising the integration of microneedle arrays with a novel signal splitter (reference needed). This integration will enable the simultaneous monitoring of foetal heart rate and aEEG. The student will shape this objective through the approach in objective 1, with platform microneedle arrays to ensure that the signals they generate are reliable, consistent, and free from fluctuations or variations. There is also scope to move in the direction of triggered therapeutic release from the microneedles if the student had preference to move in the direction. Objective 3: Testing the microneedle foetal monitoring electrodes on phantom foetal scalps and on adult volunteers. Following full ethical approval, the student will work directly with the clinicians in the supervisory team to test their devices in adult volunteers. The electrodes will be benchmarked against the gold standard technique of EEG. This research will lead to transforming foetal monitoring during labour, building on well-established neonatal monitoring techniques to enable accurate brain function assessment intrapartum and early intervention to reduce hypoxic brain injury. |
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