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Engineering in Medicine, Special Issue on Incontinence Technology

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Abstract:	In November 2023, the Institution of Mechanical Engineers hosted the 14th Incontinence: The Engineering Challenge, the latest in its series of highly multidisciplinary two-yearly conferences designed to inform, challenge, encourage and inspire those keen to develop improved technology for diagnosing, treating or managing incontinence. It was to this close community of colleagues working in academia, industry and clinical settings that we turned when we were invited to guest-edit a special issue of Part H on 'incontinence technology', and so many of the papers appearing here are by authors who have presented at recent conferences. Together, they paint a colourful picture of the breadth of current activity in the field, and the diverse expertise required to tackle the complex challenges associated with incontinence.

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Editorial, Pete Culmer and Alan Cottenden

In November 2023, the Institution of Mechanical Engineers hosted the 14th *Incontinence: The Engineering Challenge*, the latest in its series of highly multidisciplinary two-yearly conferences designed to inform, challenge, encourage and inspire those keen to develop improved technology for diagnosing, treating or managing incontinence. It was to this close community of colleagues working in academia, industry and clinical settings that we turned when we were invited to guest-edit a special issue of Part H on '*incontinence technology'*, and so many of the papers appearing here are by authors who have presented at recent conferences. Together, they paint a colourful picture of the breadth of current activity in the field, and the diverse expertise required to tackle the complex challenges associated with incontinence.

Understanding bladder (dys)function

The special issue opens with two papers that describe work being conducted to model the biomechanical behaviour of the bladder. Either through physical simulation or computational methods, this research is valuable in providing tools to gain a better understanding of how the bladder functions, both when all is well, or when it misbehaves. Mosayyebi and Caruga describe a novel physical bladder model, designed primarily to facilitate improvements in urinary stents, but in tandem advancing our understanding of urinary voiding. While it can be difficult to represent the complexities of active musculature in the bladder wall, this work shows the virtue of using simplified models which can readily represent a range of shapes, sizes and biomechanical parameters while allowing precise and repeatable examination of urodynamic profiles. Complementing this work, Silva et al explore the use inverse finite element analysis to determine the biomechanical properties of bladders. The team examine cases of continent and incontinent behaviour, thereby providing a valuable insight into how these fundamental properties relate to the real-world experience of those with incontinence.

Instrumentation

Instrumentation is a mainstay in diagnosing and treating incontinence, and also in managing it when it can't be (fully) cured. This area has seen significant change over the years, particularly through the integration of digital technology and the next four papers provide a fascinating diversity of novel examples. Urodynamic testing to diagnose lower urinary tract dysfunction is commonly conducted in the somewhat artificial 'static' conditions of the clinic and there has long been an interest in developing mobile measurement systems, providing the opportunity to monitor bladder function under dynamic ambulatory conditions, more representative of the patient going about their everyday life. In the first paper, Zareen et al. describe their recent work on methods to analyse the data from such ambulatory monitoring, enabling classification of clinically relevant events from these complex data. Monitoring bladder function is not only important in diagnosis but – for some conditions – it can provide feedback for near real-time treatment. In the second paper, Majerus et al. describe a novel closed-loop system in which signals from the bladder are detected and used to provide stimulation to counter adverse bladder contractions that might otherwise lead to leakage. The remaining two papers relate to managing incontinence more effectively through smart systems which provide targeted and timely feedback. Cotterill and Schroeder describe their development of a smartphone app which gives people living with incontinence an intuitive personalised portal to a wealth of useful information and advice on managing their

incontinence effectively which they would otherwise have to track down from a prohibitive multiplicity of sources. Next, Hellmold et al. report on novel smart technology which aims to provide caregivers of absorbent incontinence product users with timely prompts when their product needs changing, with the potential to significantly improve quality of care.

Underlying science

The next four papers focus their work on advancing the fundamental science underlying the development of improved absorbent 'containment' products for managing incontinence. These works provide critical foundations to inform and catalyse much needed product innovation. The first two papers focus on incontinence associated dermatitis (IAD), a common problem among absorbent product wearers. Morecraft et al. seek to elucidate the role of friction between skin and product, while Owen et al. investigate the potential utility of impedance spectroscopy for measuring the severity of IAD, of relevance to those wanting to objectively measure the efficacy of novel – and existing - treatments. Almost all single-use absorbent products for incontinence contain granules of superabsorbent polymer (SAP) and in the third paper Biel et al. describe their work to understand how the SAP properties that they can measure in the laboratory relate to the performance of the absorbent products in which they are used. In the fourth paper, Vaittinen et al. address the important topic of the sustainability of single use absorbent products, an area which is receiving ever-increasing attention due to their profound environmental impact.

Future needs

Last, but not least, our final four papers look to the future, each flagging needs for improved technology for diagnosing or managing incontinence and suggesting ways forward. The first two papers have their roots in the recently published 7th International Consultation on Incontinence[1], to which the authors of the papers contributed[2,3]. The consultations bring together international panels of experts who review the literature every five years or so to provide clinicians with up-to-date evidence-based guidelines for diagnosing, treating and managing incontinence. The papers here draw on the same evidence base but tailor their findings for an audience of those keen to identify unmet needs and develop improved technology: Gammie and Wachter look at instrumentation for urodynamic testing[2]; while Fader et al. consider products for managing incontinence[3]. The final two papers focus in on two specific management product categories, Rantell concentrating on vaginal pessaries and Moore et al. on intermittent catheters.

The collected works in this special issue highlight the continued need for engineering innovation to address the multifactored challenges associated with incontinence. While the major drivers in this field remain centred on improving the performance of products and improving our understanding of fundamental processes, it is evident that factors of social and environmental responsibility are becoming more prominent and embedded into healthcare legislation. The Greener NHS[4] mandates a move towards net Zero Carbon emissions (with similar moves in the EU[5]), while the United Nations Sustainable Development Goals (SDGs) challenge us to consider universal provision of healthcare and sanitation[6]. Given the research represented here, it is evident that we have skilled researchers who are helping to address these challenges, and we look forward to revisiting them in a future special issue.

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