REAL MATERIAL ETHEREAL

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Along that vein:
Redesigning the experience of clinical intravenous access

Abstract

This report discusses a practice-based research project that investigated how the design of objects, systems, and processes for clinical access to veins could improve safety, hygiene, and patient experience.

Venous access devices such as peripheral intravenous catheters and cannulas play an important role in patient management. They are inserted to allow intravenous administration of complex drug treatments, blood products, and nutritional support without the trauma associated with repeated needle insertions. Current systems, processes, and procedures for venous access in health care settings are sub-optimal. One in three intravenous devices stop working or fall out during use, yet there is limited understanding about why these devices fail. These factors, combined with clinicians' lack of knowledge of best practices, procedures, and products results in significant health system costs, unnecessary pain for patients, and increased risk of medical complications.

Our design challenge was to develop a venous access system that improved accuracy, simplified procedures, and reduced infection and waste. To understand complex issues holistically and to discover design opportunities, we used a human-centred design methodology to identify, synthesise, and visualise people's motivations, tasks, and interactions around venous access use in clinical settings. Findings were mapped and integrated with existing knowledge about venous access through highly participatory processes that engaged key stakeholders, and reflected their experiences and aspirations. Following this phase, the creative techniques of discovery, such as drawing, prototyping, and iterative testing generated insights and unexpected connections that are at the heart of innovation.

The designed system addressed venous access procedural accuracy, staff education, environmental sustainability, patient experience, device efficiency (certainty), and hygiene. It proposed a suite of products, technologies, and procedures to promote a more efficient, less invasive, and safer venous access experience.

Introduction

This project report discusses our research investigation into how the design of objects, systems, and processes for clinical access to veins could improve safety, hygiene, and patient experience.

In clinical settings, venous access devices allow liquids—medications, blood products, fluid replacement, or nutritional support—to be administered intravenously to patients without repeated needle insertions each time there is a need to change the intravenously delivered treatment. Administering directly to the vein through the blood circulation is the fastest way to deliver substances to the body. They are the most commonly-used devices in medical procedures—in Australia, 30 million intravenous (IV) devices are used annually.[1]

An estimated 80% of patients admitted to hospital are given an intravenous device.[2] Despite their frequency of use in health care settings, current systems, processes, and procedures for venous access are sub-optimal. One in three intravenous devices stop working or fall out before treatment is completed, and there is limited understanding about why these devices fail. Almost half of hospital patients given peripheral IV catheters are discharged without these even being used for delivering intravenous fluids during their stay.[3] In emergency departments, there are few accepted guidelines about when and under what conditions patients require peripheral intravenous catheters;[4] they are administered on a 'just in case' basis. Clinicians lack knowledge of best practice, procedures, and products to deliver treatment products intravenously, including the role of good hand hygiene and proper aseptic technique to prevent infection. These factors result in unnecessary pain for patients, along with increased risk of catheter-associated Staphylococcus infection and other medical complications.[5] There are also huge cost implications; ineffective practices around IV treatment cost the Australian health system at least $700 million a year.[6] All of these issues could potentially be addressed by system- or process-level design interventions.

Figure 1. A peripheral intravenous (IV) cannula inserted and taped in place

The Venous Access project was a 12-month collaboration between Monash University Art, Design and Architecture, Monash Health and Multigate Medical Products, a leading Australian medical manufacturer and supplier. The project was led by Monash Design Health Collab, a research laboratory with a focus on medical technology and health and wellbeing. The laboratory's investigations use design practice as well its outcomes to create new knowledge relevant to the healthcare field.[7] We used design thinking and co-design methodologies in combination with industrial and experience design methods to more deeply understand the needs of end-users—for this project we worked with clinical staff and patients at Monash Medical Centre in Clayton, Melbourne, who interact with intravenous systems and settings. Our core challenge was to develop an innovative system for venous access to minimise infections and waste while maximising efficiency and compliance. The research project involved three main stages; Discovery, Design, and Implementation. These correlate with the design process phases in the Double Diamond model (Figure 2) that is used in human centred design projects. Here, divergent thinking (generating knowledge and ideas) and convergent thinking (evaluating and synthesizing) are repeated twice; once to define the problem, and again to create the solution.[8] Human-centred design is a creative approach to problem-solving as well as a mindset. It focusses closely on people's needs, experiences, and goals, which means acknowledging their perspectives and involving them as end-users throughout each stage of the design process. Design solutions are more likely to meet people's needs and address core issues underpinning the situation from which the problem emerged.

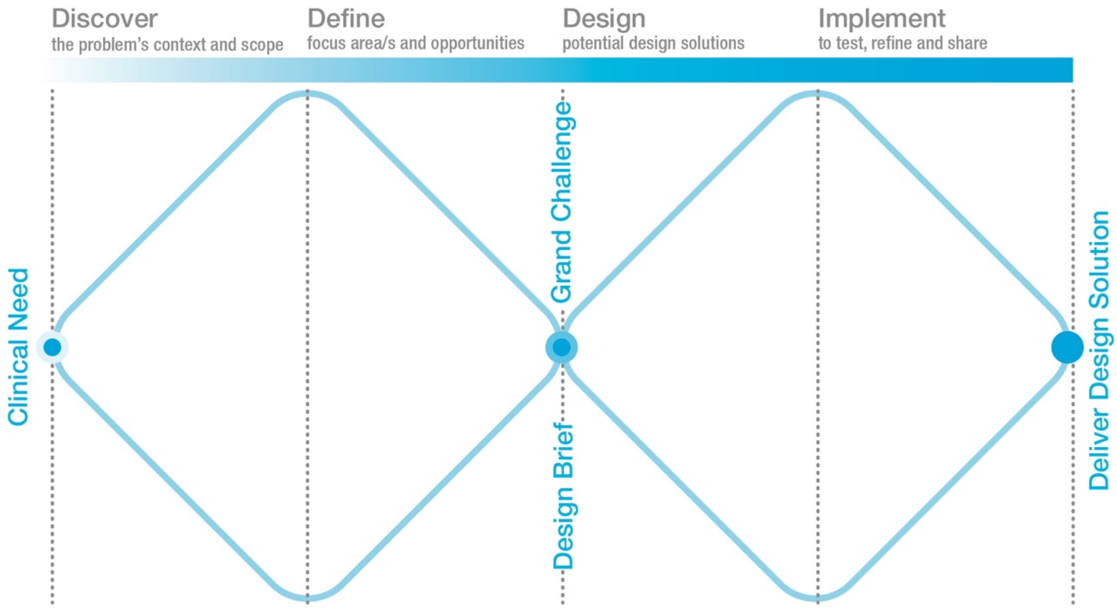

Figure 2. The Double Diamond model adapted for the Venous Access design research project.

The Discovery Phase

In the Discovery Phase, designers aim to understand and empathise with the people who will experience the product or service they create. This delivers more meaningful and useful design solutions[9] by orienting designers' mindsets towards user needs and behaviours from the start. Prior to conducting qualitative research in a hospital, our background 'desk' research established the feasibility of design-led research into vascular access. A literature review investigated existing knowledge around global best practice in venous access procedures, products, and systems. The literature indicated that current devices had undergone limited design improvement for many years, suggesting an opportunity to embed new technologies and systems for reducing medical complications and cost. We conducted a competitor analysis of venous access devices and systems and how they addressed similar problems. This identified existing products' relative strengths and weaknesses, providing a foundation for possibilities in the ideation phase. To obtain analogous insights we also looked at how completely different industries were addressing similar problems.

The medical devices' environments of use and workplace culture—clinical staff's attitudes, behaviours, and knowledge—were crucially implicated in considering design solutions. Monash Design Health Collab researchers spent several weeks in the Emergency Department at Melbourne's Monash Medical Centre, observing the clinical processes, environments, and interactions that IV treatment is situated in. Field research was carried out using contextual inquiry, an approach that combines observation and talking to people (in this case, hospital staff) on-site in the context of the environment under study. This grounded research participants in their actual lived experiences so they were less likely to generalise their views and omit detail. Notes and annotated photographs were compiled to identify areas of difficulty or inefficiency (Figure 3). Observations began with reviewing the hospital environment, and included all patient interactions with clinicians through treatment and after-care. We observed the clinical procedure and process flows associated with intravenous treatment of patients to evaluate the impact of venous access devices on patient outcomes associated with bacterial transfer and infection. We also studied post-clinical circumstances and time frames. Each of these 'touchpoints' unearthed areas of opportunity for the design team to improve procedural efficiencies and patient experience.

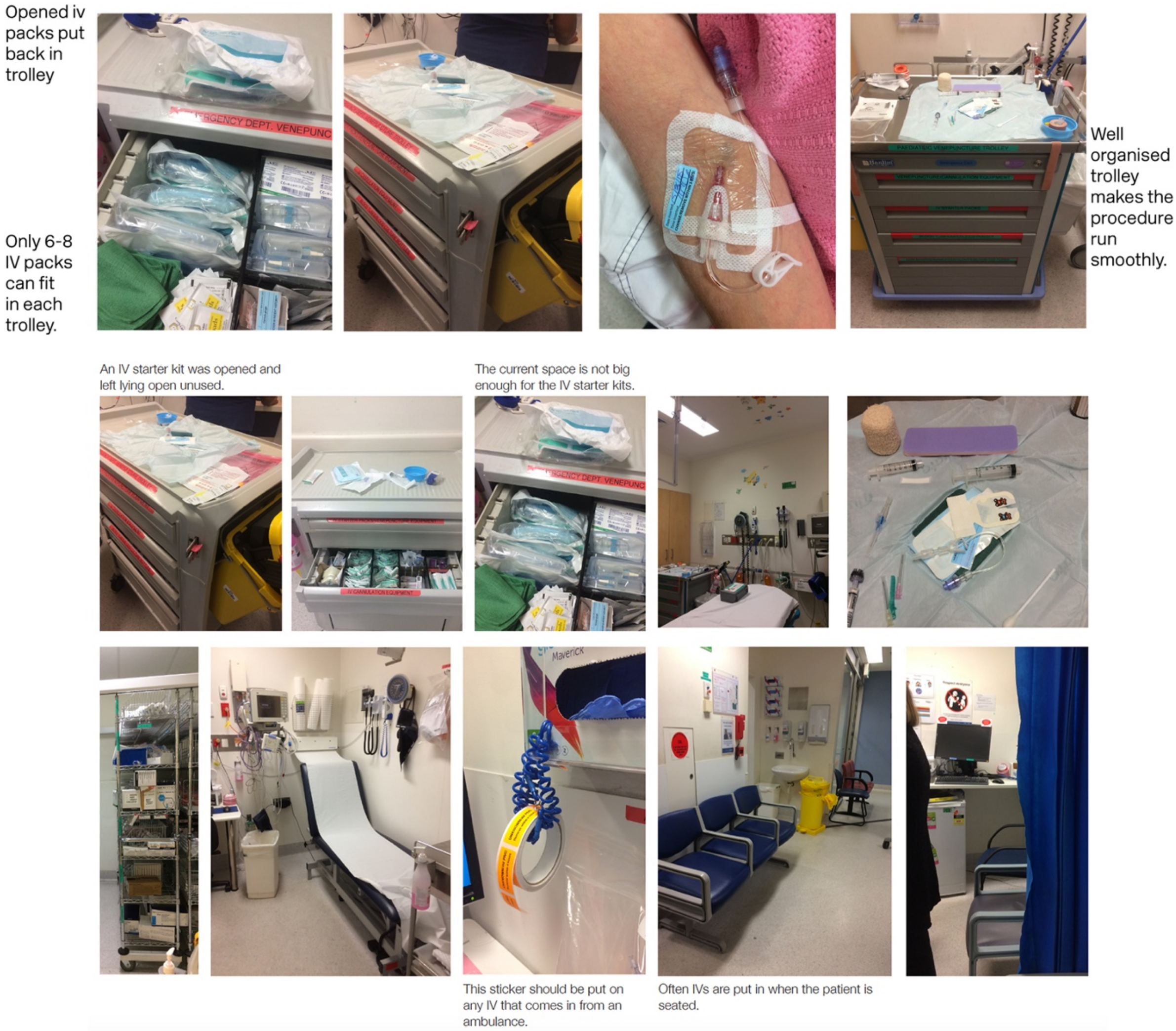

Figure 3. Observation activities photographed and annotated to capture the clinical environment around intravenous treatment.

Our Discovery Phase included mapping, where field observations and literature research were brought together to help connect designers with the people they are designing for. We developed personas that represented groups of clinical staff—and through empathy mapping we articulated what they might feel, think, do, and say. A stakeholder map visualised the individuals and groups who interact in the clinical environment, while journey mapping connected the systems, interactions, and attitudes that affect stakeholders, and therefore might inform our design considerations (Figures 4 & 5). While to some degree these maps are based on assumptions, they help turn qualitative data into insights. They are built on the premise that the motivations, needs, and interactions of the target audience hold the key to design solutions.

Figure 4. The Venous Access project's Stakeholder Map.

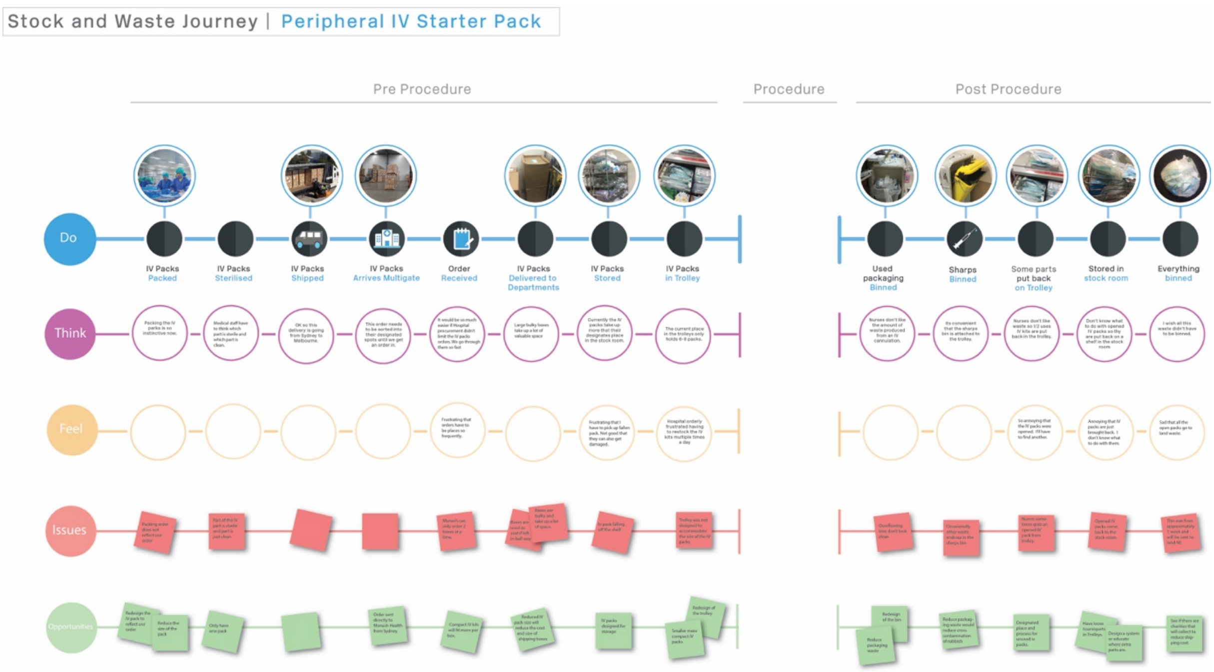

Figure 5. Product use Journey Map.

Our research had isolated some considerations that negatively impacted on venous access systems and procedures. These included:

- High numbers of patients being inserted with the 'just in case' cannula
- Poor technique in keeping tools and equipment sterile and free from contamination
- Lack of staff confidence in their skills
- Failure to adhere to procedure

Towards the end of the Discovery Phase, we started to define the problem by making sense of all the opportunities identified. We asked: what matters most? Which should we act on first? What is feasible? The goal here was to develop a clear creative brief that framed the fundamental design challenge.

It was clear that problems associated with venous access were neither simple nor singular. They were not simply device-based but were multifaceted, comprising a lack of knowledge and awareness, poorly designed products and infrastructure, inefficient systems, and processes that did not align with the needs of individuals. While the solution would deploy industrial design methods and outputs, it could not be a one-size-fits-all approach and needed to be adaptable to varying needs and environments. Analysis of these issues and opportunities led to the formulation of the Grand Challenge, which was to design ways for the intravenous treatment process to guarantee accuracy, simplify procedures, and reduce infection and waste (Figure 6).

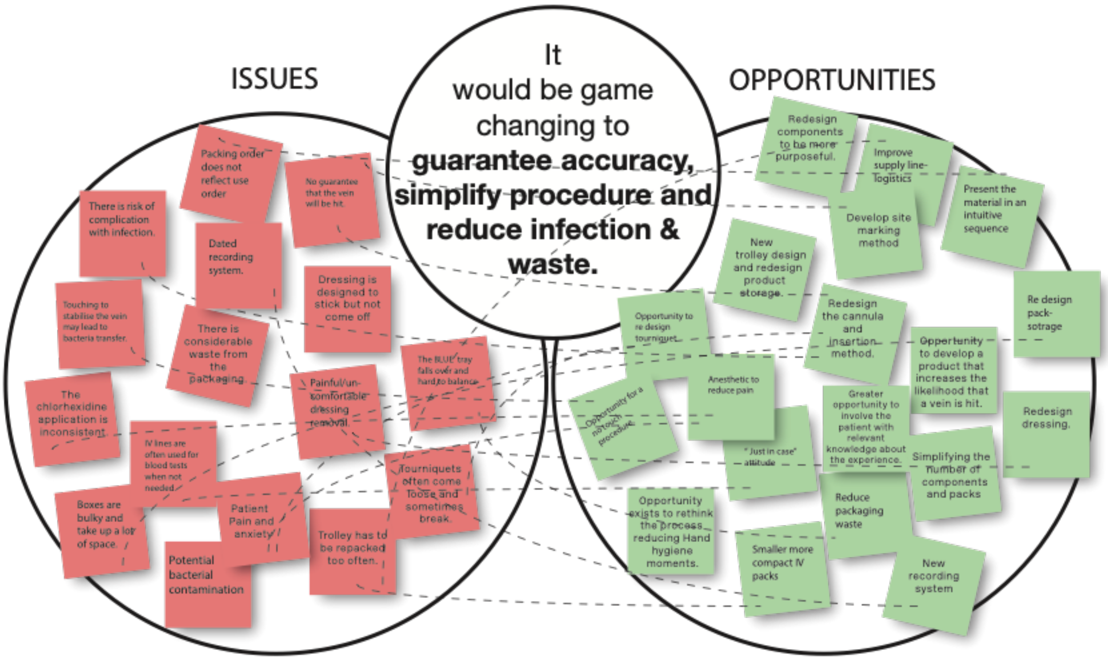

Figure 6. Issues and opportunities unearthed in the Discovery phase inspired the project's Grand Challenge.

The Design Phase

Human-Centred Design research—which drove and informed this design project—embraces the multidisciplinary collaboration of both designers and non-designers[10]. This approach lies at the heart of co-design, where the people who will use the design solution are placed as experts of their own experience and are empowered to make creative contributions to the design process.[11] All workshop participants—designers and non-designers alike—are encouraged to be actively engaged in idea generation and concept validation throughout the Design phase.

Our design team facilitated a co-design ideation workshop at the start of the design phase (Figures 8–11). Participants included clinical staff, one former patient who had experienced clinical intravenous access, Multigate designers, and Monash Design Health Collab designers —all brought together over half a day to brainstorm initial design possibilities around the Grand Challenge. Workshop activities were designed to promote maximum creative output around guided activities. Following a project overview and a presentation to workshop participants about the Discovery research, participants completed a divergent design exercise in the form of a 'brain dump' to capture initial ideas at an early stage in the workshop. Next, participants were given four themes derived from our Discovery that guided the conceptual refinement while still addressing the Grand Challenge (Figure 7).

Figure 7. Four themes that guided the convergent Key Topics idea generation activity.

Figure 8. A clinical expert set the problem context at the workshop outset.

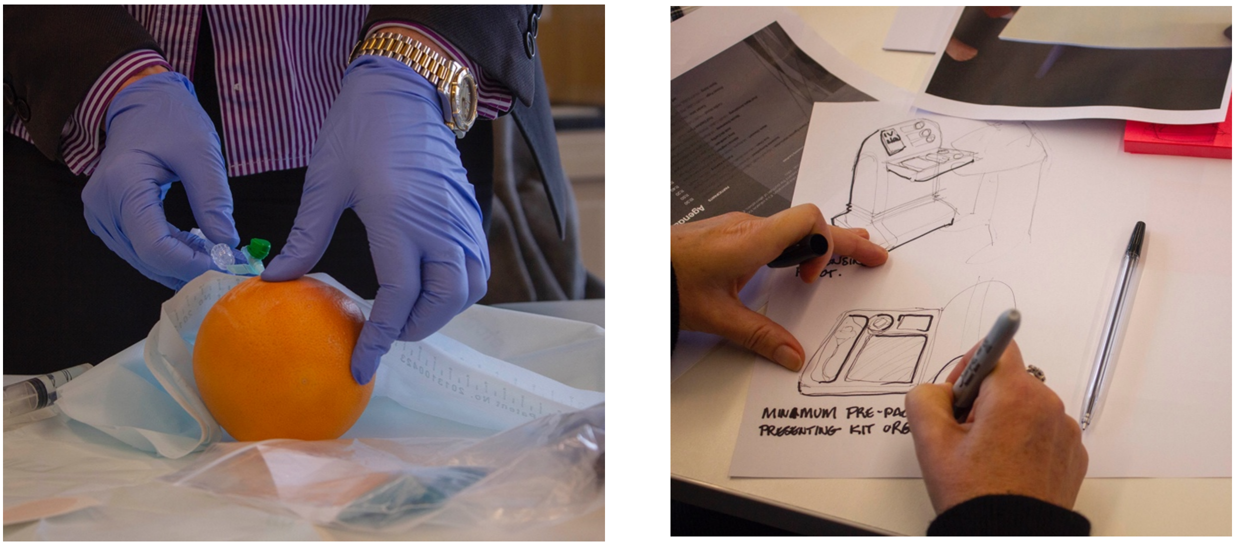

Figure 9. Hands-on workshop activities. These included analysing the process of inserting a cannula (left); and sketching ideas for IV Starter Packs (right).

Figure 10. Workshop participant sketching ideas for venous access devices.

Figure 11. Reviewing concepts produced at the workshop's idea generation session.

To prioritise design possibilities from the creative session we asked participants to reflect on which ones they felt offered the most opportunity to improve the venous access patient experience. Participants were asked to review the goals and Grand Challenge for the project and make concept selections based on their experience and knowledge. This distilled the range of ideas into 17 concepts to develop further (Figure 12).

Figure 12. A sample of the chosen concepts from the workshop.

Concept Development

Concepts from the workshop idea generation across the four themes encompassed two broad domains:

1. Venous access efficiency (reduced human contact), simplification, and sustainable waste.
2. Bacterial visibility, risk recognition, and communications around when it is safe to proceed.

Concept development towards design solutions was system-based, comprising products, technologies, and procedures. The following examples of our design interventions operate at both product and system levels to address the Grand Challenge.

Theme: Sustainability

Central to reducing waste was reimagining the IV packs that contain intravenous products. Two Starter IV pack varieties were designed: Slim Line and Roll Out. Rather than storing products in plastic bags as with existing packs, the redesigned Slim Line packs are moulded, flat, and stackable (Figure 13) improving storeroom and transport efficiency. This design aspect alone has a flow-on effect that enhances sustainability, since whenever you improve efficiency at product level other aspects of the product's life cycle such as warehousing, packing, and transport are positively affected. Items within the pack are arranged in a sequential layout to guide the user in the correct steps for venous access using the products it contains.

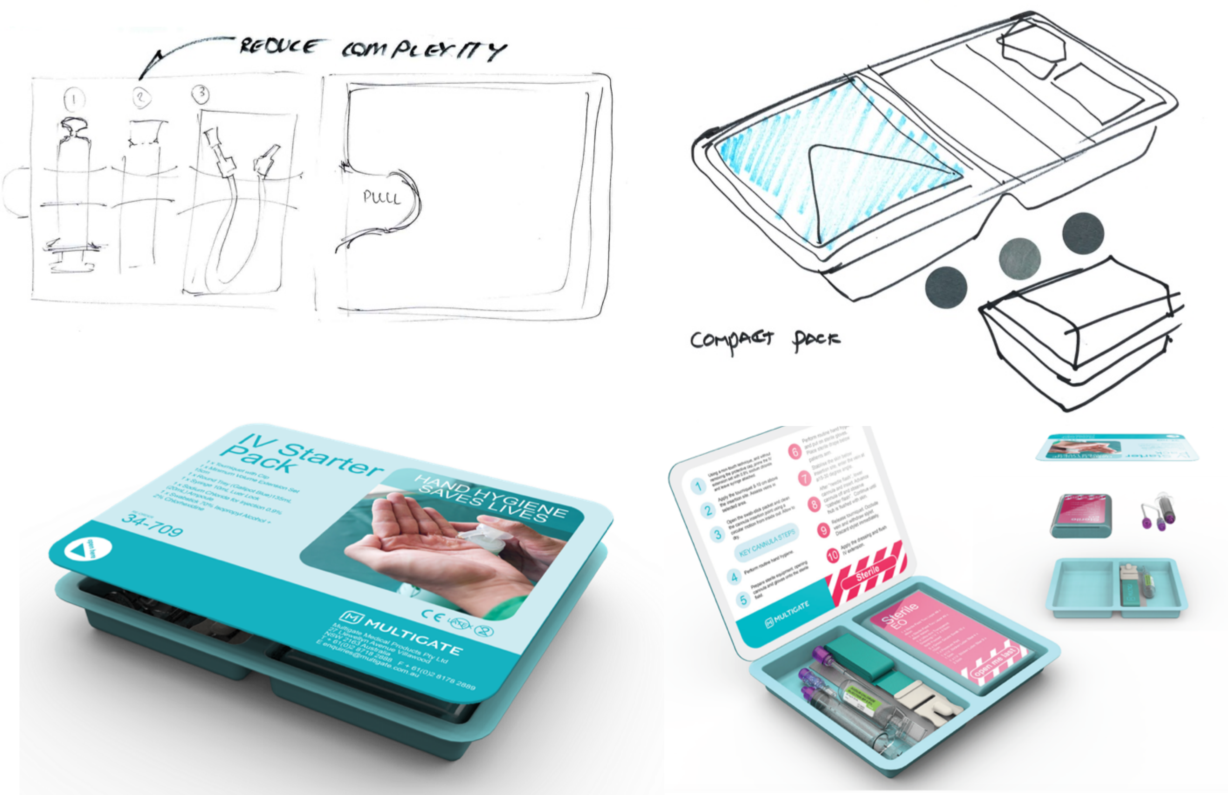

Figure 13. Initial concept sketches and final redesigned IV Starter Pack in stackable Slim Line form.

The Roll Out IV Starter pack (Figure 14) controls the order of components used during the IV procedure and provides clear distinction between steps.

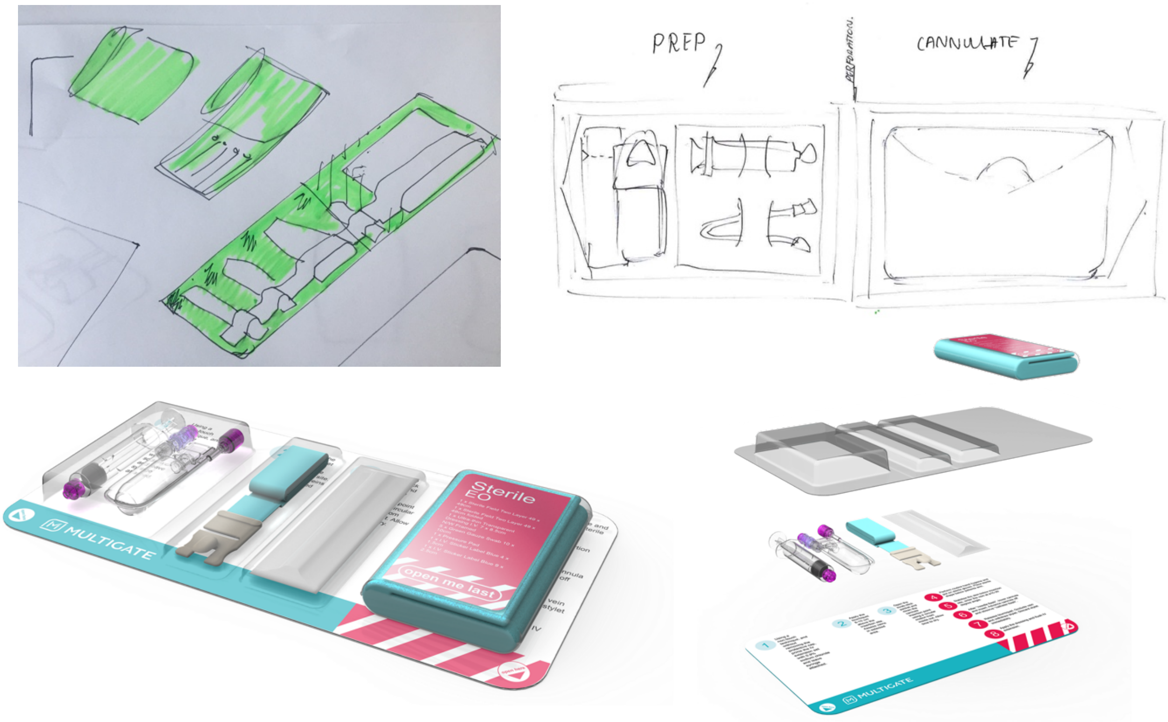

Figure 14. Initial concept sketches and final redesigned IV Starter Packs in Roll Out form.

Theme: Education

There were two unexpected insights from the Discovery Phase—education and empowerment—that led directly to design interventions. We used IV product packaging to educate and inform staff as end users of the pack contents (see Figure 13). The pack's outside reminds users of the need to maintain hand hygiene during venous access product use. The pack's inside lid provides clear, simple, and precise instructions to inform and educate inexperienced users on key cannula insertion steps. The pack lid's internal face (Figures 13 and 15) provides simplified instructions for less frequent users. This aimed to provide assurance, build confidence, and reduce the chance of incorrect use.

Figure 15. Informative messaging on IV Starter Pack for clinical staff users.

The other insight was the need for patients who are given an intravenous device to act in the best interests of their own health and wellbeing while they are being treated intravenously. Patients rarely question a procedure or treatment, feeling that they lack specialist knowledge, and being stressed about their condition and the clinical environment (Egerton-Warburton and Ieraci, 2013). By adding a text-based communication ('call nurse if in pain') to the cannula dressing as a call-to-action for the patient should the site of their intravenous treatment need attention, we empowered patients to better manage their venous access experience (Figure 16).

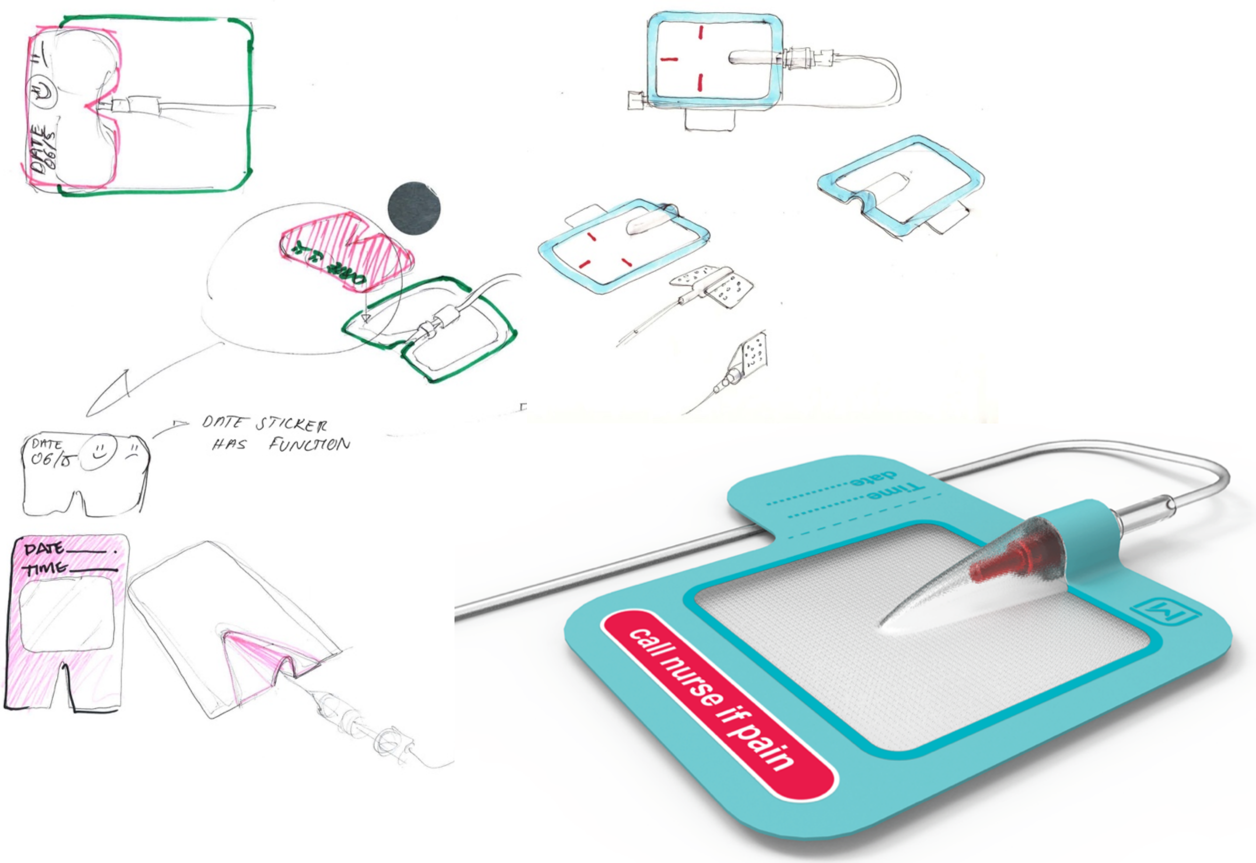

Figure 16. Initial concept sketches and final redesigned IV hub dressing with call-to-action messaging.

Theme: Patient experience

Each of the individual items in the IV Starter packs was redesigned to improve its effectiveness in actual use, whether to address device efficiency, certainty, stability, or hygiene. For example, the bandage dressing that secures the cannula in place was redesigned to increase the area of adhesion (decreasing the chances of the device moving or falling out), while allowing maximum visibility of the cannula insertion site under the skin to improve the clinician's ability to monitor the condition of a patient's IV insertion site. Semi-rigid plastic creates an improved seal around the hub (Figure 15). The IV cannula hub was redesigned to be smaller and without unnecessary ridges, reducing irritation and pressure on the IV insertion site (Figure 17).

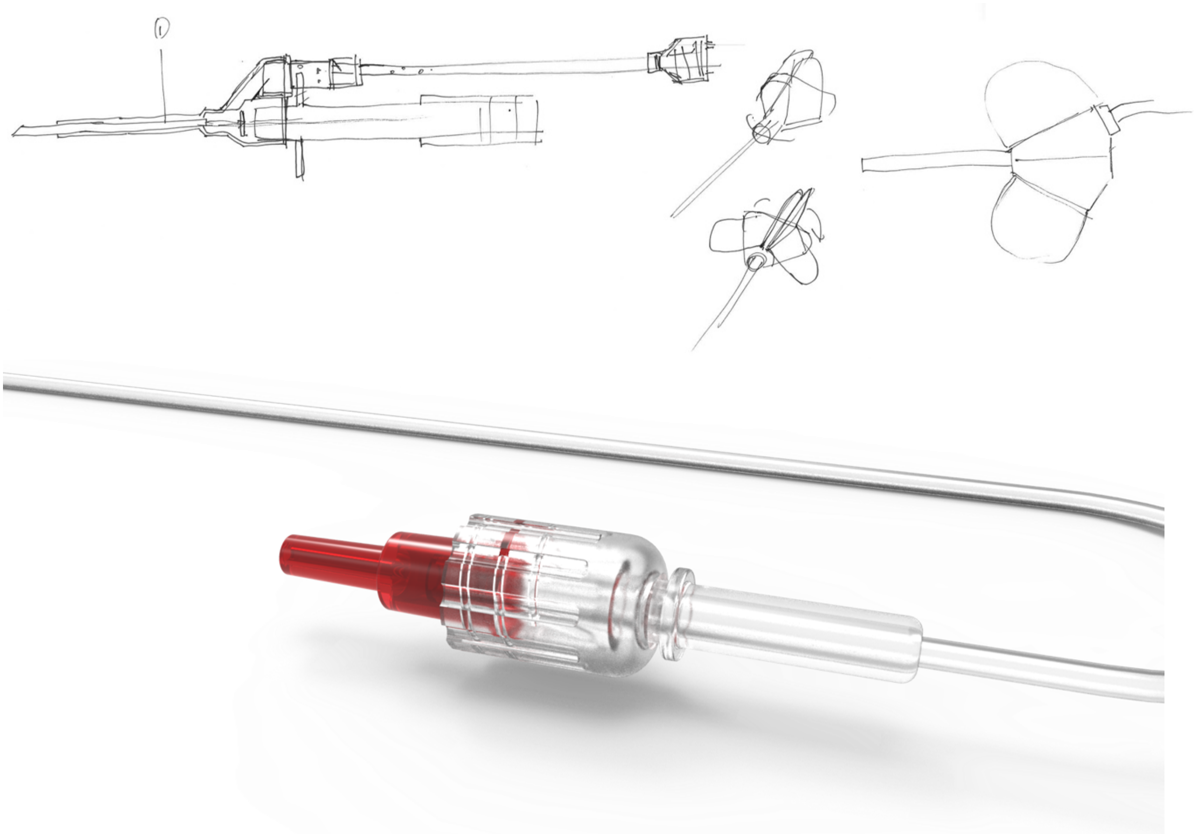

Figure 17. Initial concept sketches and final redesigned IV cannula hub.

Theme: Certainty

Concepts that addressed the ‘Certainty’ theme aimed to deliver a successful IV patient experience each time. A routine IV insertion process involves restricting blood flow to the IV area through the use of a tourniquet. We redesigned the tourniquet cleat to reduce pinching, make it more reliable when locking, and be able to be attached to the patient’s garments during their hospital admission. The concept uses a two-action system—first pull tight, then then lock into the cleat (Figure 18).

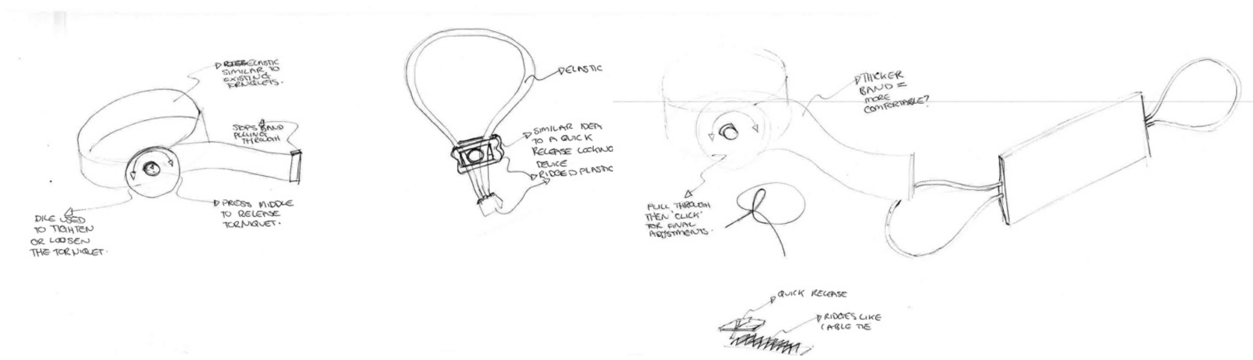

Figure 18. Initial concept sketches and final redesigned tourniquet cleat.

The Implementation Phase

Our original project proposal in this year-long design research project did not include developing high-fidelity prototypes for clinical trials or usability studies, where form, aesthetics usability, and interaction could be evaluated. Instead, this project involved two rounds of iterative design prototyping in close collaboration with clinical specialists, who were invited to give feedback on the concepts under development. Rapid prototyping translated concepts into a realisable and tangible form, enabling the designers to test their ideas. Low-fidelity prototypes, quick and cheap to produce, allowed rapid feedback and conceptual iteration.[12] The goal in prototyping is not to finish a given design, but to create opportunities for improvements, test a concept's strengths and weaknesses, and prompt further creative investigation through design development.[13] Our project hand-over to Multigate Medical Products comprised detailed CAD assemblies and physical prototypes for intellectual property management, and a series of presentations that detailed our proposed products and technologies and how these addressed the identified issues around venous access procedures. Multigate's anticipation of the clinical impact these design innovations might have compelled them to begin commercialisation of the redesigned patient dressing and tourniquet upon project hand-over. With over 80% of hospital-admitted patients receiving IV treatment annually in Australia—and with Multigate claiming 60% of market share in hospital procedure packs and medical consumables—the potential impact of these improved venous access systems and products is high.

Conclusion

Peripheral intravenous access systems involve the most commonly-used devices in medical procedures and have a high failure rate leading to high cost, increased waste and risk of infection. To date there have been limited design interventions for improving systems and processes for venous access. This practice-based research used human centred design to develop improvements to the products, systems, and processes for clinical access to veins, minimising infections and waste while maximising efficiency, compliance, and a positive patient experience. It involved three project phases. In the Discovery Phase we aimed to understand the context, systems, processes, and settings around IV use in hospitals to define the problem and identify opportunities that might be addressed through design. The Design Phase allowed broad ideation and the opportunity for stakeholders to co-create design solutions with the design team. The chosen concept direction is being commercialised through the Implementation Phase. Prototyping and feedback cycles resulted in prototypes that are currently undergoing market development, potentially improving clinical outcomes for hospital patients Australia-wide.

Endnotes

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