Veindicator

Appendices
Peripheral intravenous catheter (PIVC)

Peripheral intravenous catheterization (PIVC) is one of the most common minimally invasive medical procedures performed in hospitals today. Up to 80% of all patients admitted to hospitals worldwide will have a peripheral intravenous line inserted in the forearm or hand to administer fluids, medications, and blood products. Today's hospitals rely on IV catheters as essential tools to deliver IV medications, blood products, and nutritional fluids to patients. Approximately, 90% of all patients entering the hospital environment for care have some form of intravenous therapy during their hospital stay. Site selection is arguably the most important step in ensuring successful venipuncture or cannulation. Health professionals are encouraged to locate a vein that is long, straight and accessible while ensuring it is not near a bony prominence. The most common veins used are the basilic, median cubital or cephalic veins of the forearm (Figure 2) as they allow for the placement of a variety of different sized cannulae (needles) and do not restrict the activity or movement of the patient. That is to say, the patient is able to carry out normal activities while the cannula is in situ.

PIVC necessities.

- Tourniquet
- Cleaning stick and wipes
- Gloves
- Needle
- Syringe and bottle of saline
- Bionector
- Cannula
- Blood tubes and adapters
- Cotton wool & tape

PIVC step-by-step

1. Check saline is in date and clean bottle with an alcohol wipe
2. Draw up your flush using your needle and syringe
3. Prep your bionector with a small amount of saline - this is to remove the air
4. Prepare any blood bottles by connecting them to the adapter
5. Apply the tourniquet 3 to 5 inches from where you want to insert
6. Select an appropriate vein from the hand till the elbow
7. The vein should be as large and straight as possible
8. Hold the cannula firmly with your index and middle fingers on the wings and thumb on the back of the cannula to control the needle
9. Clean the area of the skin
10. Apply traction to the skin to stabilise the vein
11. Insert the tip of the cannula at an acute angle
12. Keep skin tight to enter the vein
13. Gently advance the shaft of the cannula
14. Remove the needle from the cannula
15. Attach the bottle to take blood sample
16. Release the tourniquet
17. Secure the cannula with the strips of tape
18. Place rest of the dressing over the cannula
19. Clip the end of the bionector so it is neat and secured
20. Wash your hands and thank the patient

2. Skillz lab

Research objective:

- How is the procedure executed in normal circumstances?
- What are the difficulties in the procedure?
- How do we observe the procedure?
- What are the complications of the procedure?
- Which actions have to be performed

Blank areas to be researched:

- Difference between normal and emergency situation
- Experience the procedure
- Empathise with executors of the procedure
- What are the difficulties in the procedure
- Which actions have to be performed

Location:

Eramus MC

What:

Lesson for medicine students to practice the procedure

Findings:

1st case: Difficult to puncture student

- If the vein is difficult to puncture, you can vary with a larger or smaller needle, insert the IV more slowly/quickly.

2nd case: Middle aged woman with chemotherapy

- If the patient is older, they will have a less firm skin. Because of the chemotherapy, the patient will have stiff veins. These two will cause rolling veins. To help this, the nurse can tighten the skin with two fingers.
- If the vein is too difficult to puncture, find another spot - distal to proximal (hands to shoulder). If that does not work, try the foot.

3rd case: an infection has occurred.

- With infection, take the IV out. The veins will get firm really quickly.

4th case: the patient is in shock.

- When in shock, the veins will get more narrow, this leads to that the patient is not pierceable anymore. Always try to put in an IV, if this does not work, puncture an artery.

Practical assignment insights:

- In practice, feeling is more important than trying to locate the vein visually.
The first step is to put on the tourniquet, after tap the veins lightly, feel if you can locate a vein. Remember the spot and get your needle and puncture. Why you have to remember is because after feeling the first time, you have to make the spot sterile, where after you can not touch the location.

When do you know when you are in the vein? That is a matter of feeling. If you feel the needle sliding, you are in the vein.

When demonstrating to the students, the teacher missed on the first try.

Even the fact that you can see the veins better, puncturing on the hand (IV) is more difficult. The veins are more narrow and fragile.

Putting in an IV is super painful after missing a few times, the body can get into a shock because of the pain.

The student assistant has had a bad experience when practicing putting in IV’s. With her, the first two tries did not succeed.

You can know the depth of the vein by feeling a bit of resistance. This occurs by going through the vein wall. If you are in the vein, there is less resistance.

While performing the procedure, you come one hand short. As seen in the picture, how the student holds the three way valve with two fingers, while tightening the skin with the other two.

There are a lot of parts needed for the procedure and there are a lot of steps to be taken.

During the procedure, I noticed that you come one hand short to hold things for quick insertion. Maybe make the product also to help the nurse with other steps.

I was nervous trying it the first time, because after localising, I was uncertain whether if I had remembered it well. And I was insecure while inserting. It would have been helpful to have some sort of reference.

Existing products

VeinViewer

Allows you to switch colors within the image window. This unique feature assists clinicians in customising the projected image based on factors such as skin tone, density of hair follicles and room brightness.

VeinViewer’s Eyes On Patient (EOP) hands-free technique allows you to easily integrate this technology into your normal procedure; determine the location of valves and bifurcations and avoid these problematic structures.

Find the optimal access point and vessel target that is sufficient for the length of the catheter.

Navigate curves in the vessel.

Visualise a rolling vein.

3. Market research

VeinViewer IV-eye

This is the method used by the IV-eye. By transmitting NIR light from both sides of the target area, the device transmits light deeper into the patient’s tissue than the reflective method, therefore displaying deeper veins more clearly.

NIR Light is transmitted straight into the skin from above. This method is more suitable for viewing superficial veins close to the surface of the skin, and is the method utilised by almost all of the other near infrared vein imaging devices currently available on the market.

The IV-eye is placed flat (on a patient’s peripheral limb (lower arm or back of hand) and near-infrared light to illuminate the skin and the subcutaneous tissue. The near infrared (NIR) light is transmitted by means of light emitting diodes (LEDs) in the flexible wings. The near infrared light penetrates the patient’s skin, is absorbed by the haemoglobin in the blood, and passes through the fat and other tissue surrounding a vein. The camera on the underside of the IV-eye captures an image of the blocked light and a digital processor creates an image of the underlying vascular structure. This is then shown on an LCD display situated on the top of the device.
Table 3: Advantages, disadvantages and costs for each technology.

<table>
<thead>
<tr>
<th>Method</th>
<th>Color Visor</th>
<th>Pressure Sensor</th>
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<th>Infrared</th>
<th>Ultrasound</th>
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<td>Various</td>
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<td>No risk for the environment</td>
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<td>Suitable for outdoor light</td>
<td>Suitable for outdoor light</td>
<td>Portable</td>
<td>Portable</td>
<td>Wearable</td>
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| Cons            | Simple      | Simple           | Various | Various | Various     | Various       |
|                 | No risk for the environment | No risk for the environment | No battery | No battery | No battery | No battery   |
|                 | No light sensitivity | No light sensitivity | No risk for the environment | Needle gauge | Needle gauge | Needle gauge |
|                 | No risk for the environment | No risk for the environment | No battery | No battery | No battery | No battery   |

**Costs:**
- **Price (USD):** $2,000 - $20,000
- **List Price:** £2,900 - £4,600
- **Extended warranty option:** Available

**Performance:**
- **Performance:** The IV-eye uses Df² technology, this VeinViewer provides a clear view of the vein site.
- **Portability:** The IV-eye is a touchscreen smartphone.

**Videos:**
- **VeinSite**
- **Vivo-light**
- **Accuvein & Flex**
- **VeinViewer**

**Sources:**
- [www.christiemed.com](http://www.christiemed.com)
- [www.vuetekscientific.com](http://www.vuetekscientific.com)
- [https://www.christiemed.com](https://www.christiemed.com)

**Other Sources:**
- [Novarix Ltd](http://novarix.com/)
- [Accuvein Inc](http://www.accuvein.com)

**Fees:**
- **Development fee:** £2,000
- **Ex-distributors fee:** £2,000
- **Tales of user interest fee:** £2,000

**Warranty:**
- **Warranty:** 1 year
- **Extended warranty option:** Available

**Pricing:**
- **List Price:** £2,900 - £4,600
- **Extended warranty option:** Available

**Technical Details:**
- **Technology:** NIR LED 850nm
- **Apps:**
  - **VeinSite**
  - **Vivo-light**
  - **Accuvein & Flex**
  - **VeinViewer**

**Information:**
- **Device Type:** Portable and reliable vein finder.
- **Weight:** 9.7 ounces (275g)
- **Dimensions:** Weight and dimensions unspecified

**Usage:**
- **Pre-hospital use:** Portable and reliable vein finder.
- **Technical Details:** NIR LED 850nm
- **Applications:**
  - **Surgical**
  - **Emergency Medicine**
  - **Intensive Care**

**Competitive Products:**
- **VeinSite**
- **Vivo-light**
- **Accuvein & Flex**
- **VeinViewer**

**Regulatory:**
- **CE Mark ISO Class:** (I, II, IIa, III)
- **FDA Class:** (I, II, III)
- **FDA 510K:** Approved

**References:**
- [http://novarix.com/](http://novarix.com/)
- [https://www.christiemed.com](https://www.christiemed.com)
<table>
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<tr>
<th>Product Description</th>
<th>Battery or AC Power</th>
<th>Technique</th>
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Extended programme of requirements

A. Development

a. Design
1. Prototype shows enhanced image of veins through infrared
2. Can be used for pilot trial in September
3. Is a minimum viable product
4. Prototype is in TRL 3
5. Is suitable for healthcare context
6. Can be successfully integrated into healthcare context
7. Has necessary functionalities for facilitates venipuncture procedure
8. Is suitable for every age, skin and body type
9. Has low invasiveness

b. Production
1. Prototype is made out of PLA
2. Model is suitable for 3D printing
3. Production method is 3D printing
4. Material is suitable for medical context
5. Next prototype is made out of SLS
6. Prototype has low manufacturing costs
7. Future prototype is suitable for mass production

C. Verification
1. Prototype is tested with end-user
2. Prototype is facilities procedure
3. Safe to use
4. Prototype quickens venipuncture procedure
5. Prototype is tested with end-user
6. Prototype complies to medical ISO standards
7. Prototype follows medical guidelines
8. Prototype is facilitates procedure
9. Prototype is tested with end-user

C. Use

a. Charging
1. With a 7.000 mAh battery, the prototype can be used for a day
2. Charging ports are reachable from the outside
3. Battery can power all electronic circuits
4. Prototype does not depend on the mains (230 V)
5. Charger takes all mains voltages

b. Carrying
1. Prototype is pocketable
2. Prototype has dimensions of 145*95*70 mm
3. Prototype is lighter than 0,5 kilograms

C. Use flow
1. Positioning
2. Prototype uses a stand to attach to furniture
3. Stand can be attached to different furniture in a hospital setting
4. Stand is adjustable to differences in height of furniture
5. Stand is made out of medical approved material
6. Stand has a minimum distance of 20 cm from the subject
7. Stand is adjustable in height to allow for different heights in use (thickness)
8. Stand is lightweight
9. Stand is detachable from prototype
10. Prototype is movable in 1 and 3 direction (height and position along the arm)
11. Stand can be positioned precisely above subject
12. Prototype can be positioned and adjusted perpendicularly to subjects arm
13. Arm and arm placement should be clear
14. Stand is not in front of projection
15. Stand does not interfere with the procedure
16. Stand has an offset of 1 cm both sides when holding prototype
17. Prototype is stable when attached to stand
18. Prototype is less expensive than existing products
19. Prototype can be positioned and adjusted perpendicularly to subjects arm
20. Prototype uses a stand to attach to furniture

b. Carrying
1. Prototype uses an LED array of 850 nm to illuminate the veins
2. The LED array provides a high contrast between the vein and surrounding tissue
3. The LED array is concentric aligned around the camera
4. The LEDs are powered by the prototype
5. The LEDs use a voltage of 12 V for optimal intensity
6. The LEDs provide uniform lighting
7. The LEDs provide constant illumination
8. The LEDs provide uniform illumination
9. The LED array is concentric aligned around the camera
10. The LEDs are powered by the prototype
11. The LEDs use a voltage of 12 V for optimal intensity
12. The LEDs provide uniform lighting
13. The LEDs provide constant illumination
14. The LEDs are powered by the prototype
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18. The LEDs provide uniform lighting
19. The LEDs provide constant illumination
20. The LEDs are powered by the prototype
21. The LEDs use a voltage of 12 V for optimal intensity
22. The LEDs provide uniform lighting
23. The LEDs provide constant illumination

Appendix B
17. A camera with high sensitivity to the sub-spectrum of infrared radiation is used.
18. The camera has a resolution of 5 MP.
19. Camera images in real time.
20. Camera provides high quality images.
21. Camera is commonly available.
22. Camera focus is preset to 15 m to assure images.
23. Camera is fed into a processing computer.
24. Camera is inexpensive.
25. Camera is easy to implement.
26. Camera can image in low light and full light conditions.

30. Processor provides high contrast images.
31. Image is suitable for image processing.
32. Prototype is operable in daylight.
33. The illumination system works in different surrounding lighting systems.
34. The camera set up only captures infrared light.
35. The camera set up only captures infrared light.

4. Processing Hardware:
1. Processor is commonly available.
2. Processor can run software.
3. The processor is compact.
4. The processor is used for prototyping.
5. The processor is single board processor.
6. The processor fits in the prototype.
7. The processor is a single board processor.
8. The processor is used for prototyping.
9. Processor can run software.
10. Processor is commonly available.
11. Processor can be linked to subcomponents.
12. Processor can be programmed and controlled.
13. Processor can be linked for subcomponents.
14. Processor can power subcomponents.
15. Processor has onboard wifi connector and ethernet connection.
16. Processor has a CSI (camera serial interface) connector.
17. Processor is supplied with less than 1 A connection.
18. Processor is supplied with 5v connection.
19. Processor has linux operating system.
20. Processor has at least 1 GB operating memory.
21. Processor has onboard wifi connector and ethernet connection.
22. Processor has a CSI (camera serial interface) connector.
23. Processor can power subcomponents.
24. Processor can be linked to subcomponents.
25. Processor can be programmed and controlled.
26. Processor can run software.
27. Processor is commonly available.
28. Processor can power subcomponents.
29. Processor can be linked to subcomponents.
30. Processor can be programmed and controlled.
31. Processor can run software.
32. Processor is commonly available.
33. Processor can be linked to subcomponents.
34. Processor can be programmed and controlled.
35. Processor can run software.

2. Software:
1. When button is pressed, software is activated.
2. Computational power needed is low to minimise resource needed.
3. Software must be able to process the image.
4. Software reduces the image noise.
5. Software reduces image noise by blocking hair.
6. Software can be adjusted for different needs.

5. Display:
1. Image created is displayed back to end-user.
2. DLP lightcrafter module projects image to user.
3. DLP is readily available.
4. DLP is programmable.
5. DLP can be used with embedded host processors.
6. DLP is ultra mobile.
7. DLP is powered by RPi.
8. DLP can be adjusted to suit differing needs.
9. DLP is firmly placed in embodiment.
10. DLP is optically alligned with the camera.
11. Visible light projected must be blocked by the IR filter.
12. Projected light is absorbed by inner surrounding of embodiment.
14. Image is projected directly on top of the actual veins.
15. Vein location information is returned to end-user.
16. Returned information is 100% reliable and consistent with reality.
17. Eliminated surrounding light interference.
18. Projected light is absorbed by inner surrounding of embodiment.
19. Reduced noise and reflection back to camera.
20. All projected light is reflected by filter.
21. Image displayed has the exact field of view as the image captured.
22. Image displayed is 50*70 mm.
23. Access to focus is subject of test.
24. Image displayed has same optical allignment as image captured.
25. Image displayed back to end-user.
26. The intuitive use increases integration.
27. User test have to be conducted to optimise prototype.
28. Minimal functionalities improve understanding of the product.
29. The minimal viable product can be adjusted to fit into different healthcare contexts.
30. Additions can be made to optimise prototype for differing contexts.
31. Additional software can be added to increase accuracy of the analysis.
32. Software can be adjusted for different needs.
33. Software reduces image noise by blocking hair.
34. Software uses algorithms to extract vein pattern.
35. Software reduces image noise by blocking hair.
36. Software can be adjusted for different needs.

3. Hardware:
1. The product does not contain any cavities or sharp edges.
2. The product still works after dropping it from 1 meter height.
3. The product is splash proof.
4. The product is compact.
5. The product is mobile.
6. The product can withstand a heat up to 50 degrees.
7. The product contains minimal functionalities for it to be viable.
8. The product can be easily adjusted to suit differing needs.
9. The intuitive use increases integration.
10. The minimal viable product can be adjusted to fit into different healthcare contexts.

4. Process:
1. Plastic casing can be separated for recycling.
2. Plastic casing can be separated for recycling.
3. Nuts and bolts can be separated for recycling.
### Imaging

Interview Roland Huisman 26/03/2019
Associate professor Applied Physics
Department Imaging Physics (ImPhys)

Visible is until 650 nanometer
When researching filters, look to the relative response of
Visible is until 660 nanometer

When looking for LEDs, look at the spectral bandwidth. For you application, test with light
emits 890 nm, the spectral bandwidth will be 888-892.

### Processing

Interview software expert - Interview milk weehaeser 26/03
Software developer/Microsoft
Geert Assistance by developing software for image pro-
cessing

Use OpenCV - That is an open source software where different image processing building blocks can be found.
It is ready made modules which can be used. These can then be tested and put after each other. The commands
for every step are stated with the building blocks and can be used. Step
Try the different image processing possibilities with one image
try the different commandos
find a suitable combination
put the different models subsequently from each other
Run the script
look on OpenCV for existing projects
You can ask questions on stack overflow

Quick test setup
use different backgrounds to test how you can lower the
computational needs to a minimum [6,7].
A software program was written that projected the
dot set on the screen, captured a cam-
era image of the test pattern, measured the location of the
dots, and calculated the average difference between
the x and y positions of the points in the projected and
captured images, as well as the rotation of the captured
image with respect to the projected image. The program
system is activated -> display product name, after
working process
Software requirements
Working process
1. If - on/off button is pressed -> start up system
When system is activated -> display product name, after
few seconds run script (see image processing for detailed
specifications)
When the script is activated -> show enhanced image of
veins (see software for detailed specifications)
If on/off button is pressed again -> script will stop run-
ing -> display product name after few second product
will shut down
Working process
In - on/off button is pressed -> start up system
When the script is activated -> show enhanced image of
veins (see software for detailed specifications)
If on/off button is pressed -> script will automatical-
ly stop running after a couple of minutes (exact time still
to be determined)

Software is also used to ensure that the vein image is
projected directly on top of the actual veins themselves.
The projector light, which is colored green with a green
filter to simulate the green LED A test pattern, consist-
ing of four pixel red dots located at the corners of a rectangle centered in the image, is projected on the
screen and the location of the dots on the camera is
measured in order to determine the parameters need-
ed for the magnification (different in the horizontal and
vertical directions), rotation, and translation (different in
the horizontal and vertical directions) of the vein image
in order to achieve correct alignment with the subject’s
veins. (paper: The clinical evaluation of vein contrast
enhancement)

A software program was written that projected the
dot test pattern onto the screen, captured a cam-
era image of the test pattern, measured the location of
the dots, and calculated the average difference between
the x and y positions of the points in the projected and
captured images, as well as the rotation of the captured
image with respect to the projected image. The program
displayed the measured and calculated information on a
computer monitor and repeated the measurements every
7 s to allow the effects of translating or rotating the
optical axes to be observed continually. If the projector
image and the camera image were exactly at the focal
distance, the average difference between the x and y
positions of the points in the projected and captured
images would be zero, and there would be no detectable
rotation angle between the two images.
Appendix E

Integration

1. User test
Interview Sonja Paus-Buzink
Department: applied ergonomics and design
How to user test
Goal: Find a way to test the interaction with the prototype while doing it now.
- Give them tasks similar to the envisioned working principle.
- Create a scenario, give the user a story.
- Use paper prototyping to test expectations.
- See where and the time of process.
- Goal: Find a way to test the interaction with the prototype.
- How to user test
- Department: applied ergonomics and design.
- Interview Sonja Paus-Buzink.

1. User test
- Make different concepts.
- Ask for preferred aesthetics.
- Look into medical device legislation.
- For a medical product, check medical usability.

2. Context variation by design
Interview Wouter Kersten
Research: Make product fit to multiple contexts.
Context Variation by Design (CVD) is an approach and mindset that acknowledges and in fact cherishes complexity, i.e., reality, in order to address contextual variations and large scale issues. More specifically, it uses as a starting point that large scale issues occur in multiple contexts, e.g., regions, countries, user groups, or other words: use cases. By intentionally sourcing views and insights from these multiple contexts from the start a rich issue analysis and corresponding design space is created. This design space acts as a basis for rich (more) creative solutions with contextual variations that have benefited from bringing together collective intelligence early on. This is opposed to approaches aiming at an optimal solution for one given context followed by scaling to new contexts. The latter in practice often means that this ‘upgrade’ for new contexts only constitutes small variations of the initial solution, which do not really meet the needs. All in all, by taking into account different use cases, e.g., regions, countries, use cases, one can achieve more adaptable and adaptive integrated product and business architectures can be developed.

The CVD approach and mindset explicitly aims for large scale well to new contexts.
- Logical capabilities, usability, fit context and functionality.
- Successful adaptation is increased by increasing technological capabilities, usability, fit context and functionality.
- A good approach to acknowledge and in fact cherishes complexity by focussing on characteristics of the problem, i.e., reality, in order to address contextual variations and large scale issues.

- Address the globalising and connected society.
- Problems and needs of different user groups are still very similar.
- Address the globalising and connected society.
- Find which attributes are distinguishable from others. Find core characteristics.
- Find which attributes are distinguishable from others.
- Find which attributes are distinguishable from others.
- Choose scope.
- Keep reachability of stakeholders in mind, you don’t have to satisfy every use case for 100%.
- Don’t satisfy but go for satisficing.
User test - students

1. Patrick MSc student EWI

1. I think it is a product to scan a certain body part.

2. I would put my arm in the scan and I would press a button, the scan would be on and I would be able to see the veins.

3. I think it will be a useful product.

4. I would turn the product on, the veins will be shown, I would have an on off button, and a button to change the intensity, because I can imagine that not everyone is the same and that different types of skin will need different intensity. And I will have a third button to reduce intensity. So you can tune the device.

5. Oh I would not use it myself, the device will turn on. The device will give an indication of where the best site is to place an IV if not the doctor will mark an indication of where to insert the IV and then turn it off again. Then place the IV when the hand is under the light, or the hand can be taken from underneath and then the IV can be put in place.

6. The home screen is seen, and it is not changing, so I think I have to change the intensity to where it is focused and it will automatically turn on. Oh it is not turned on, maybe I need to press a button. When I press the button I see that the image is changed. If I press the button again, the scan goes off, so I press the last button.

7. Straightforward.

8. Location

9. -

10. -

11. I prefer the one only showing the veins, it is more clear.

12. -

2. Dan - MSc student IDE

1. Scan.

2. I don’t know where and how to put my arm, maybe have some directional or placement indicator.

3. If it is a scan, I am concerned of the difference in thickness of arms. Adjustment would be nice to have to have the focus at the same point for every arm. Furthermore, I have also a tipping concern. The product goes far out and looks like if I will touch it I will tip over. Maybe it is attached to a bed or cart.

4. Do you also have knobs? Do you turn on the light? Knob to turn up the projection intensity. For light skin people easy to see, for dark skin people not easy to see. Knob to move the scanning area. I would not want to have a lot of functionality, because it is used to decrease my insertion time. I would automate it as much as possible. It detects an arm underneath it should go on. And just an up and down arrow to adjust height. Or it can tell me step by step how to go to that vein location. Keep information projected above as little as possible.

5. I would put my hand underneath, press scan, have an issue here, I can not see anything. Maybe if it is attached to a bed or cart.

6. It would be nice if it would auto change colour for me. You have a scanner and also an image. So you lose the brightness of the surface and also an image. So if the brightness will be in this category, the projected light should be green, and if it is in the light skin category, it should be blue (for instance).

7. Check if the position of the patient in relation to the position of the doctor; laying in bed or sitting in a chair. The doctor will be higher or lower, see if the product will give support in this category, the projected light should be green, and if it is in the light skin category, it should be blue.

8. Location.

9. -

10. -

11. I prefer the non-inverted image, to me it is more clear.

12. -

3. Rahul - MSc EWI

1. I would put my hand underneath and press something on the side to activate the system.

2. I would have a zoom in and out button to determine focus. Also I would have a tune knob to change between the visible range of light.

3. I would have a zoom in and out button to determine focus. I would have a zoom in and out button to determine focus.

4. For now there are 3 buttons, on/off, s and c. You have to make an image of a person and a button to change the colour of the light for me?

5. Roleplay: A patient comes with badly visible veins and needs an IV. How would you expect to use the product and create an image of the veins to support this procedure? -

6. You need to tape a toothpick in the place of the veins.

7. It would be nice if it would auto change colour for me. You have a scanner and also an image. So you lose the brightness of the surface and also an image. So if the brightness will be in this category, the projected light should be green, and if it is in the light skin category, it should be blue (for instance).

8. I would be able to see the veins.

9. What kind of information would you want from the device?

10. Location

11. I prefer the non-inverted image & which one do you prefer?

12. Extra comments:
1. If I don’t have a screen, then I would not be able to see the projection at all times.
2. y
3. Best insertion location.
4. what you are doing.
5. your hands interfere with the light, and with the screen, you would still be able to see your hand.
6. On the computer, then I would like to have a screen on the product.
7. Because during the procedure, I would be in the light beam with my hands.
8. Meike - MSc - IPD
9. I think I would be at the doctor and I think the stand can be adjusted to focus on my hand.
10. First I would make sure the light settings are good.
11. I would like to have the vein image tattooed on the hand. Haha no but would be nice.
12. I would like to see the veins and insertion location after the hand is pulled away from underneath.
13. I would like to have a screen on the product, because during the procedure, I would be in the light beam with my hands.

1. I would put everything on the top, so that you will have some sort of remote control.
2. After insertion, I would press the on/off button again to turn the device off.
3. I think you need to put your arm underneath, keep it in place for a while so it can scan and then if it is ready, it will automatically go to the next step.
4. I would not put anything on the top, because it will wobble too much. So I would place them at the bottom of the stand and on the spine of the stand, one button for on/off. The next button would be a button to start the scan and these two will be settings.
5. Ludo - MSc - IPD
6. 4. Meike-MSc - IPD
7. 5. Some kind of imaging process, I think that something will be captured underneath the box.
8. I would put my arm underneath and set the right height with the stand. I now only have the idea that the only interaction is setting the height.
9. I would put the on/off button on the stand, because you don’t want to turn it off accidentally when you set up the device. Furthermore, I would have to buttons to change light intensity. I can imagine that it will be nice if you can put your arm underneath and change the intensity to check if you can see the veins even better. But the product will have to be more stable than when you change the intensity that it won’t wobble.
10. I would like to have a vein image tattooed on the hand, ha ha no but would be nice to be able to still see the veins and insertion location after the hand is pulled away from underneath.
11. I think only the veins, I think it would be more clear.
12. I would like to see the vein image tattooed on the hand, have no but would be nice to be able to still see the veins and insertion location after the hand is pulled away from underneath. Because if you want to insert, you will have your hand in the way of the projection.

1. I think I would need to put your arm underneath, keep it in place for a while so it can scan and then if it is ready, it will automatically go to the next step and show the lines of veins. I don’t think that the user can activate the system, I think the device will give a sound to let the user know it is ready.
2. I would put all the buttons on the device or on a thing next to the device and the system will go on and run.
3. 3. I think you need to put your arm underneath, keep it in place for a while so it can scan and then if it is ready, it will automatically go to the next step and show the lines of veins. I don’t think that the user can activate the system, I think the device will give a sound to let the user know it is ready.
4. I would put nothing on the top, because it will wobble too much. So I would place them at the bottom of the stand and on the spine of the stand, one button for on/off. The next button would be a button to start the scan and these two will be settings.
5. 5. After I give you instructions where to place your hand, I would press on/off button. Oh I see that the scan starts automatically. Then I would press the second button, I think it is freeze. It changes color but I don’t really know what the function is. Oh I think you can use it when the image is not really clear, or maybe when you have a different skin color.
6. 6. I would press the second button.
7. Well, it is not easy to match, but I will manage. But maybe for the next version, it will be nice to have more space. If I would be a doctor, I would be bent over the product and it will be in your right, it maybe will cause shade, and you can’t really move freely, I think you can value that.
8. I think the information I would want is what the right type of light is for each skin type, maybe you can install it on the device that it would give the best option automatically.
9. And maybe the device can also give a sound notification when the vein situation changes, so the doctor knows he/she has to alert.
10. I think you need to put your arm underneath, keep it in place for a while so it can scan and then if it is ready, it will automatically go to the next step.
11. I think the right type of light is for each skin type.
12. Meike-MSc - IPD
13. 5. After I give you instructions where to place your hand, I would press on/off button. Oh I see that the scan starts automatically. Then I would press the second button, I think it is freeze. It changes color but I don’t really know what the function is. Oh I think you can use it when the image is not really clear, or maybe when you have a different skin color.
14. 6. I would press the second button.
15. Ludo - MSc - IPD
16. 4. Meike-MSc - IPD
17. 5. After I give you instructions where to place your hand, I would press on/off button. Oh I see that the scan starts automatically. Then I would press the second button, I think it is freeze. It changes color but I don’t really know what the function is. Oh I think you can use it when the image is not really clear, or maybe when you have a different skin color.
18. 6. I would press the second button.
19. 5. After I give you instructions where to place your hand, I would press on/off button. Oh I see that the scan starts automatically. Then I would press the second button, I think it is freeze. It changes color but I don’t really know what the function is. Oh I think you can use it when the image is not really clear, or maybe when you have a different skin color.
20. 6. I would press the second button.
1. A scan for some part of your body
2. I think it is a static product and that you can not move it, because it is fragile. And I think that you need different kinds of light for different types of patients. Furthermore, I think you need to put something underneath and then it will scan the object and with these images you can do something.
3. I would turn the device on with the on/off button. Now I see the logo and then automatically the veins. There is another button, which I press, and the color changes. I think that is so the light adapts to different skin types.
4. I think the basics? Like temperature, blood pressure?
5. Then I would first place your hand underneath and then press the on/off button which also directly show veins. And after the veins are visible, I would adjust the image. Now it is super blue, and green, which is making the veins less visible, so I would press the button again, and orange is making it worse, so I press again. So the button is to change the color to see veins in different depths.
6. Yes, I would press the button.
7. I think it was a good interaction, it was easy understandable
8. I think you need to put something underneath and then it will scan the object and with these images you can do something.
9. If you want to have a high and easy usability, I would leave it like this. But if you want to further develop it, I think you would need a display with temperature and extra information so everyone can use it to insert a needle.
10. Set the right height
11. I would go for inverted, because with projecting on the veins, you actually cover the product and not for the interaction. For interaction I think I would add zoom in and out and make it a digital function instead of a mechanical function. If it is mechanical, it is less precise.
12. I would prefer to reduce functionality because the product is used to decrease procedure time

8. Levels - Misc SPD
1. I think you need to put something underneath and then it will scan the object and with these images you can do something.
2. I would put the hand underneath and then I would somewhere to turn it on. I think on the top, and then you can open the device and maybe also change the height with a handle or to put it more close. And then an option for focusing.
3. This would be on, this would be focusing. I think zooming in and out would be a plus. Maybe you can have a manual and automatic focus option. The on/off would be at the side and the others on the top.
4. I would turn the device on, the on/off button. Now I see the logo and then automatically the veins. There is another button, which I press, and the color changes. I think that is so the light adapts to different skin types.
5. I can imagine that there would be something around it so you can better see the projection. Maybe you could adjust the height so I can see the buttons on top better and have more overview of the hand, or I could be seated higher.
6. I would want to save the patient’s data. I can imagine that that information could be quite useful if someone gets ill or maybe there is something else you can derive from the image. And maybe I would like to see the data on a small display on top. And I would prefer to have it as a display instead of it being projected as well, since I think people will trust a display more.
7. I would prefer to reduce functionality because the product is used to decrease procedure time

9. Placement indication, now I don’t really know where to place my hand. Or if you are in bed, maybe a stand where you can put your hand. These are more additions to the product and not for the interaction. For interaction I think I would add zoom in and out and make it a digital function instead of a mechanical function. If it is mechanical, it is less precise.

10. A scan for some part of your body
11. I think it is a static product and that you can not move it, because it is fragile. And I think that you need different kinds of light for different types of patients. Furthermore, maybe a lock function that when the product is in position to lock the position. I think you would position the on/off on a stable location, so on the side. If it is on the product, it may vibrate. The brightness I would place on the side as well. If the product is also used without stand, I would place them on top. Or maybe on the side, because then you can look at the buttons from the side.
12. I think it is a static product and that you can not move it, because it is fragile. And I think that you need different kinds of light for different types of patients. Furthermore, maybe a lock function that when the product is in position to lock the position. I think you would position the on/off on a stable location, so on the side. If it is on the product, it may vibrate. The brightness I would place on the side as well. If the product is also used without stand, I would place them on top. Or maybe on the side, because then you can look at the buttons from the side.

11. I would prefer to have shown where I should insert the iv, instead of where not to insert. And maybe it would be nice to have a line to indicate the middle of the vein, so you would have the most chance of success.
12. If you capture from the top, when inserting an iv, not only the product is in the way, you would have the most chance of success. And maybe you can do something with sound use-cues or feedback.
1. Wat vind je van de omgekeerde afbeelding, en welke heeft je voorkeur?

2. Wat zou je er van vinden als het product een injecteer locatie zou aangeven?

3. Wat vond je van het gebruik?

4. Wat denk je dat de functie van de knoppen waren?

5. Q: Rollenspel voor infuus: Put the device on. Do we use tourniquet to bring veins up?

6. Wat denk je wat de functie ervan is?

7. Q: Rollenspel voor infuus: Put the device on. Do we use tourniquet to bring veins up? This makes it way easier because the veins come up. First have a look on both arms which are very expensive. I thought it was very convenient. It was at a liver (nier) department.

8. Wat te doen als de functie van de knoppen niet werkt?

9. Q: Rollenspel voor infuus: Put the device on. Do we use tourniquet to bring veins up? Gebruikerstest - Medici / Verpleegkundigen

10. Wat zou je verwachten als je het product wilt gebruiken om een ader projectie te krijgen? Wat heeft je voorkeur voor het gebruiken? Normaal een spuit - nu een prikker (monkey face)

11. Wat zou jij het product gebruiken om een infuus aanleggen bij mij? Hoe zou je verwachten het product te gebruiken?


13. Wat vind je van de functie van de knoppen?

14. Wat vind je van het design?

15. Wat vind je van de interfacie?

16. Wat vind je van de eenvoud en feedback?
2. Interview ICU nurse

1. I don’t see a relation between blood apheresis and this device.
2. Practical challenge: bring this device to the bed of an ill patient. How to place it on a bed? Mattress is too unstable to put it on. With a clamp it might work because it can be placed at the head side of the bed. It can also be possible to attach to the OKlamp. I don’t want it to be in the workspace. Also it should be adjusted properly so it won’t fall on top of the patient.
3. Button to adjust intensity of light, depends on the effect of a change of intensity. A rotary knob would be best for this. Preferably a smooth knob because that way it can easily be cleaned. Intensity and power button are enough.
4. The button would be best on the front side because if it is on the top you cannot reach it. If it is hanging over a patient in bed. All buttons on the front side would be logical. Maybe power button on the side it for to be clearer. Rotary button for intensity in the middle on the front side.
5. Put on a tourniquet get the device, connect the device to the bed or somewhere. I power on, now I clearly see the veins. If not I would adjust the intensity. Now I insert the needle to the patient. I would adjust the intensity and power button on the side for it to be clear. Maybe power button on the side it for to be clearer.

3. Interview ICU nurse

1. It looks like a surprise box. A pump which can be attached. I would use the clamp. I would adjust the intensity and power button. A start scan button to scan. Maybe a button adjust the depth of the scan, possibly with slider. And then a stop scan button. I would place the buttons next to each other so you can work with it with one hand. See picture.
2. I would explain use of the machine shortly as introduction for the patient. Start with disinfecting, I would need an extra hand to hold the device. The hand must be placed below the machine. Now I start scanning and I would choose a vein for inserting the needle.
3. The function of both buttons is on/off and scan button. I like it that it is only two buttons because it is easy and you will not be confused with the amount of buttons. Even better would be one button for all. Power on is scanning. Maybe an extra button to adjust depth. Simplicity is key.
4. I think the scan now is a bit too big. It might be hard to perfectly align the device with the patient. Also I can be stand in the way of the doctor. A proper setup should be researched. Maybe position the clamp on the other side of the bed than the doctor will sit. Hole in the clamp. I would use a needle light cord on the top head. Flexible positioning is needed as every patient in bed is lying differently. I would like to insert the needle where indicated. So not the negative image. Probably it would not matter but I feel for me this would work best.

4. Interview ICU nurse

1. Yes, if first attached to bed, then after sterile gloves on etc.
2. Q: Can this device be used in a sterile process?
   A: No, I think this is a nice functionality. But it needs good testing to find best colours for different skin types. Besides sight you also need a lot of seeing with the hands to find a vein. Feeling the vein for me is more important. Also some experience is needed to properly find the vein.
3. Q: What was the function of both buttons?
   A: Power on/off and intensity.
4. Q: Do you recommend colouring for different skin colour would work?
   A: Yes I think this is a nice functionality. But it needs good testing to find best colours for different skin types. Besides sight you also need a lot of seeing with the hands to find a vein. Feeling the vein for me is more important. Also some experience is needed to properly find the vein.

5. Interview ICU nurse

1. I don’t see a relation between blood apheresis and this device.
2. Practical challenge: bring this device to the bed of an ill patient. How to place it on a bed? Mattress is too unstable to put it on. With a clamp it might work because it can be placed at the head side of the bed. It can also be possible to attach to the OKlamp. I don’t want it to be in the workspace. Also it should be adjusted properly so it won’t fall on top of the patient.
3. Button to adjust intensity of light, depends on the effect of a change of intensity. A rotary knob would be best for this. Preferably a smooth knob because that way it can easily be cleaned. Intensity and power button are enough.
4. The button would be best on the front side because if it is on the top you cannot reach it. If it is hanging over a patient in bed. All buttons on the front side would be logical. Maybe power button on the side it for to be clearer. Rotary button for intensity in the middle on the front side.
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6. Interview ICU nurse

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2. I would explain use of the machine shortly as introduction for the patient. Start with disinfecting, I would need an extra hand to hold the device. The hand must be placed below the machine. Now I start scanning and I would choose a vein for inserting the needle.
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4. I think the scan now is a bit too big. It might be hard to perfectly align the device with the patient. Also I can be stand in the way of the doctor. A proper setup should be researched. Maybe position the clamp on the other side of the bed than the doctor will sit. Hole in the clamp. I would use a needle light cord on the top head. Flexible positioning is needed as every patient in bed is lying differently. I would like to insert the needle where indicated. So not the negative image. Probably it would not matter but I feel for me this would work best.

Conclusion

1. / Medical sociology or making an echo. It is clear that something needs to be put underneath.
   / Looks like a surprise box.
2. / I would put it under mattress, however then I am missing the display of information.
   / I have used one at my internship. But they don’t have them everywhere because they are very expensive. I thought it was very convenient.
   / It is for the patient, I will not know how to place it on the bed. A clamp might work because it can be placed at the head of the bed.
   / Should be placed so it would not fall on top of the patient.
   / I would not put it in the bed, but over.
3. / Brightness
   / Set position
   / Light intensity - smooth skin, so it can easily be cleaned.
   / Start scan button
   / Adjust depth
   / on top, otherwise it might touch the arm.
4. / all together for clients
   / capturing image will not be necessary - if the vein situation changes, you would want
   / / no display needed
   / / if there is a display, make sure it is interchangeable with gloves as well
   / / intensity and power button are enough
   / / just the buttons on the top, so they are reachable from all sides.
   / / buttons next to each other so it is operable with one hand.
5. / Only one button was used, since it already gave the right image
   / I would first connect the device somewhere, power on and if I could not see the veins,
   / I would adjust the intensity.
   / Explain the device to patient, disinfect the insertion location, place hand below the machine and start scanning.
6. / Power on/off & Intensity
   / Changing color to adjust for different skin types is useful, however this should be carefully
   / researched.
   / On/off & scan
   / I like that it is only two buttons because it is easy and you will not be confused with
the amount of buttons. Even better would be one button for all. Power on is scanning on.
Maybe an extra button to adjust depth. Simplicity is key.

7. / Make it more child-friendly, since children have very difficult veins.
/ Make it more operable, so it is not interfering with the procedure. You have to be able to see the full arm. With a large enough distance a display will not be needed, since you already see what you are doing.
/ It should be attached to the best property but still be easy to handle
/ Size too big might be hard to perfectly align the device with the patient and it can also be in the way of the doctor. A proper setup should be researched.
/ Flexible positioning is needed as every patient in bed is lying differently

8. / It should be easy to see
/ Time needed for procedure while using product should be same or less
/ See possibilities for inserting in the neck for the carotid arteries, this is useful in the intensive care
/ Most important to me is how to place it in a bed of a patient. That should be easy and that it shines from the top on the patient.
/ Should not make contact with the patient.
/ It should be easy to clean

11. / If it is a good suggestion, that is always useful.
/ There is a difference between the best technical position and the best user friendly position to insert the needle.
/ Advice is useful, the doctor can choose to use this advice.

12. - 13./ Inverted is useful for coloured skin. So white veins for dark skin and dark veins for light skin.
/ The possibility to switch would be useful so you can determine per patient what is the best choice.
/ I would like to insert the needle where indicated. So not the negative image.
/ I would like to see the veins projected because those are the main subject.

14. / Research possibility to be able to switch between seeing an artery and a vein, this will be useful in the intensive care because of low blood pressure
/ To insert in a central line this device would be really useful.
6. Product placement

Similar existing products & their placement

**Intracranial Pressure Monitor (ICP monitor)**
This is a small pressure sensor that is placed surgically beneath the skull. It attaches to the ICP monitor at the top of the bed. It allows staff to continuously watch the ICP.

**Intravenous Pumps (IV)**
Alongside the bed there will be several poles with small machines attached. It is common to see several machines and bags of fluid at the bedside. The IV pumps deliver fluids and medications to your loved one.

**Monitors**
The monitor is a machine at the side or head of the bed. It helps to watch the heart rate and rhythm. It also gives readings of blood pressure, respiration, and heart and lung pressures when needed.
- Heart rate and heart electrical tracing (ECG)
- Oxygen levels in the blood (oxygen saturation)
- Blood pressure
- Pressure in the veins (CVP)
- Urine output
- Temperature
- All the fluids, food and drugs
- Ventriculostomy
Ventilator - breathing machine
This machine is used to help your loved one breathe and keep enough oxygen in the blood. A tube is inserted through the mouth or nose into the trachea (wind pipe) and is attached to the ventilator. The patient will not be able to talk until this tube is removed.

Kidney machines
Some patients' kidneys stop working due to their illness. The kidneys work to filter the blood and remove waste products (and in doing so produce urine) so if they fail, it is important that the machines take over this job. To do this a special large tube is put into one of the big veins in the leg or neck.

Other possible placements
Besides the possibility to clamp the prototype to an ICU device, it can also be positioned onto other objects in the ICU.

After considerations, the best location to place the product on an object which will always be present for every patient, which is the bed. Positions for placing the device on the bed, are the bed rails on either side or at the headboard. After discussing with a nurse, she suggested not to place the product where it might fall onto the patient. It would be better not to let the product hang above the patient. Thus, the bed rails would be the best option. At sanquin, the blood donation department, there also has been looked into the best placement for the product. Here, the chair also has several clamp possibilities on either side of the armrests.

Finally, there has been looked at possibilities at the general practitioners. Here also, the object the patient will be located on has clamping possibilities.

Production
After a visit to Reinier de Graaf, a researcher suggested looking at an ICU technical product specialist, provita, instead of designing an own stand. Looking at their offer, these following products can be combined to get the desired stand. See figure below.
7. Full assembly

PCB connection
Electronic components
Casing
## 8. Bill of materials

<table>
<thead>
<tr>
<th>Part</th>
<th>What</th>
<th>Model</th>
<th>Amount</th>
<th>Cost</th>
<th>Website link</th>
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<td>RPi</td>
<td>Raspberry Pi 3 B+</td>
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<td>1</td>
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<td>45 deg cold filter</td>
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