DESIGN OF AN USER FRIENDLY ECG SYSTEM

PRODUCT DESIGN
PROJECT III
MDP - 448

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P3

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BETiC | IDC IIT Bombay

This Project is dedicated to

Mr. Santosh Sawant , casual laborers & support staff IDC who passed away due to sudden cardiac arrest on 26th February 2016.

Approval Sheet

Industrial Design Project 3

titled "**Design of an user friendly ECG System"**

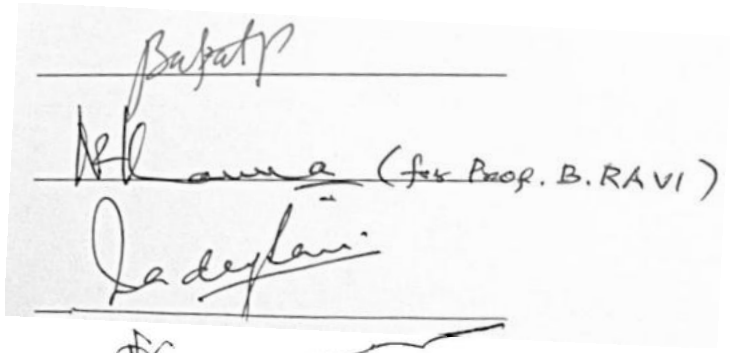
by Dattaram Chari
M.Des. (Industrial Design 2014-16)
146130003

is approved for the partial fulfillment of the requirement for the degree of "Master of Design" in Industrial Design.

Guide

Co Guide

Chairperson



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External Examiner

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Abstract

ECG , Electrocardiograph has become a routine part of any complete medical evaluation .The ECG waveform allows one to infer information about electrical activity associated with different aspects of a heart beat and is therefore of particular value for assessing an individual's cardiac rhythm and heart health. In this project, an approach of systematic redesign of the ECG is done to obtain the desired results at conceptual levels.

The project aims at intervention in areas of product usability redesigning an easy to use, cost effective aid and system to record the heart activities and make the process of ECG recording less cumbersome.

Although products which help in ECG monitoring do already exist in the market, this project differentiates itself from other products by being better at user centric design aspect and by being affordable on a slighter note.

I have tried to come up with a better model considering the findings & observations made during the project duration. The project report discuss on the existing user related problems in ECG recording and then derive to the research and redesign of the product.

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01 INTRODUCTION

1.1 Background

Cardiac arrest is having major contribution to sudden and unexpected death rate in the modern stress filled lifestyle around the globe. As per World health Organization, (WHO) , cardiovascular disease kills almost million people all round the year along with twenty million people still at risk of sudden heart failure.

What is ECG ?

An ECG is a graphic produced by an electrocardiograph, which records the electrical voltage in the heart in the form of a continuous strip graph & helps in understanding the heart activity. Every Public Health Centers and hospitals have the basic facilities of ECG monitoring system wherein a skilled ECG technicians handle the activities of the recording of the electrical signals and display of results which are analyzed by the expert doctors for further treatment. It is the key tool in cardiac electrophysiology, and plays a vital role in screening and diagnosis of cardiovascular diseases.

Electricity is conducted through the heart muscles. Many types of damage to the heart tissue can be detected with an ECG . As per standard procedure of ECG it was observed that there are some shortcomings and loopholes in the process of existing ECG recording systems . A holistic approach which can easy the existing process of ECG monitoring system will be a boon to the society.

The scope of the project is focused to understand the problems at a system level & improve the ease of product use. The learnings will be incorporated in developing a system which is can be taken for further implementation & actualization of the product.

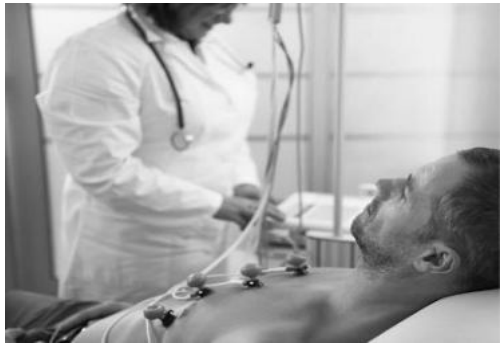
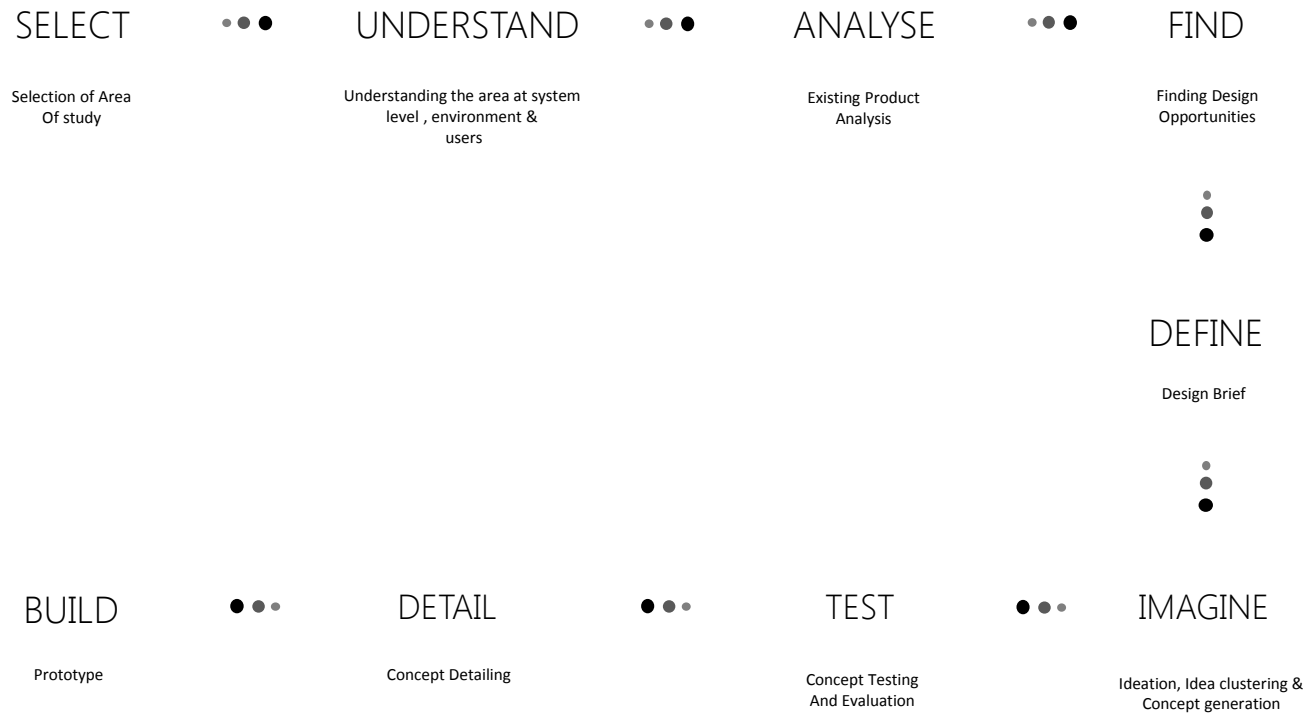


Fig. 1.1

Pic. : Author

Pic : Ref , www.pinterest.com Fig. 1.2

1.2 Design Methodology



Source : Author Fig. 1.3

02

PRIMARY RESEARCH

2.1 Data Collection

2.1.1 Understanding the Basic Functioning of Heart

To understand ECG recording process, first the basic heart activity was studied.

Location of Heart

The heart sits within a fluid-filled cavity called the pericardial cavity in the Thorax structure. (Fig. 2.1) The walls and lining of the pericardial cavity are a special membrane known as the pericardium which lubricates the heart. The pericardium serves to hold the heart in position and maintain a hollow space for the heart to expand.

Structure of the Heart Wall

The heart wall is made of 3 layers: epicardium , myocardium and endocardium. The thickness of the heart wall varies in different parts of the heart.

The Cardiac Cycle

The cardiac cycle includes all of the events that take place during one heartbeat. There are 3 phases to the cardiac cycle: atrial systole, ventricular systole, and relaxation.

Blood Flow through the Heart

Deoxygenated blood returning from the body first enters the heart from the superior and inferior vena cava. The blood enters the right atrium and is pumped through the tricuspid valve into the right ventricle. From the right ventricle, the blood is pumped through the pulmonary semilunar valve into the pulmonary trunk. Ref. fig. 2.2.

The pulmonary trunk carries blood to the lungs where it releases carbon dioxide and absorbs oxygen. The blood in the lungs returns to the heart through the pulmonary veins .From the pulmonary veins, blood enters the heart again in the left atrium.

The left atrium contracts to pump blood through the bicuspid (mitral) valve into the left ventricle. The left ventricle pumps blood through the aortic semilunar valve into the aorta. From the aorta, blood enters into systemic circulation throughout the body tissues until it returns to the heart via the vena cava and the cycle repeats.

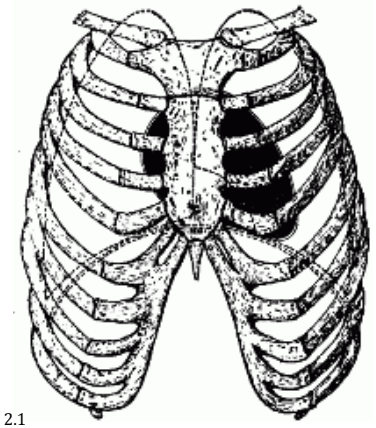


Fig. 2.1

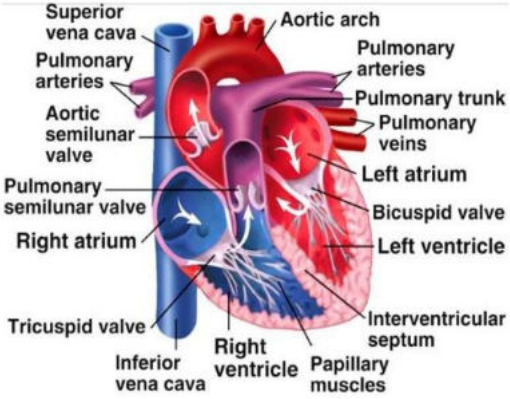


Fig. 2.2

2.1.2 Understanding the ECG

The electricity of the heart

The contraction of muscle is associated with electrical changes called “depolarization”, and these changes can be detected by electrodes attached to the surface of the body. Since all the muscular contraction is detected, the electrical changes associated with contraction of the heart muscle will only be clear if the patient is fully relaxed and no skeletal muscles are contracting.

Although the heart has 4 chambers, from the electrical point of view it can be thought of having only two, because the 2 atria contract together (‘depolarization”), and the 2 ventricles contract together.

The wiring diagram of the heart

The electrical discharge for each cardiac cycle normally starts in a special area of the right atrium called “sinoatrial (SA) node” (Fig 2.3). Depolarization then spreads through the atrial muscle fibres. There is a delay while depolarization spreads through another special area in the atrium, the “atrioventricular node” (also called AV node).

Thereafter , the depolarization wave travels very rapidly down specialized conduction tissue, the “ bundle of His”, which divides in the spectrum between the ventricles into right and left bundle branches. The left bundle branch itself divides into two . Within the mass of ventricular muscle. Conduction spreads somewhat more slowly, through specialized tissue called “ Purkinje fibers”.

The Electrocardiogram

The ECG produces a distinctive waveform in response to the electrical changes taking place within the heart . Ref Fig. 2.4.

The first part of the wave, called the P wave, is a small increase in voltage of about 0.1 mV that corresponds to the depolarization of the atria during atrial systole. The next part of the EKG wave is the QRS complex which features a small drop in voltage (Q) a large voltage peak (R) and another small drop in voltage (S). The QRS complex corresponds to the depolarization of the ventricles during ventricular systole. The atria also repolarize during the QRS complex, but have almost no effect on the ECG because they are so much smaller than the ventricles.

The final part of the ECG wave is the T wave, a small peak that follows the QRS complex. The T wave represents the ventricular repolarization during the relaxation phase of the cardiac cycle. Variations in the waveform and distance between the waves of the ECG can be used clinically to diagnose the effects of heart attacks, congenital heart problems, and electrolyte imbalances.

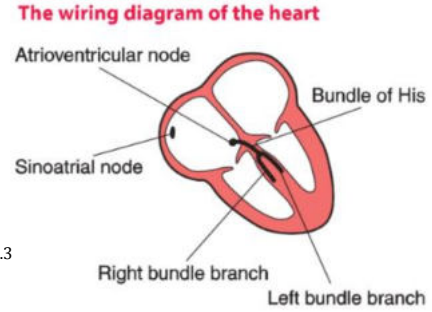


Fig. 2.3

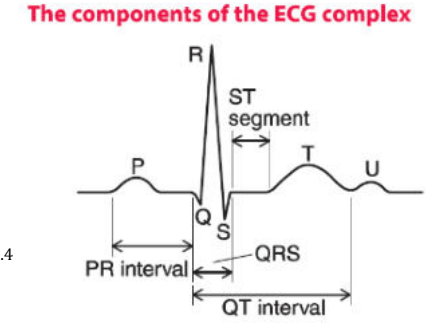


Fig. 2.4

2.1.3 Understanding the ECG Recording process

The electrical signal from the heart is detected at the surface of the body through electrodes which are joined to the ECG recorder by wires. One electrode is attached to each limb & 6 to the front of the chest.

The ECG is recorded by a trained ECG technician wherein he locates the chest electrode positions on the chest. Patient is made to be supine position. The trick is to make the patient motionless for better accuracy of recording. There are 6 chest leads V1, V2, V3 , V4 , V5 & V6 which are located by a standard procedure.(fig.2.7)The standard procedure involves counting the 4th Intercostal space from sternum cavity & placing of V1 & V2. Refer Fig 3.8. Then locate the V6 electrode below the armpit on the midaxillary line . Then locate the V4 electrode on midclavicular line below the nipple reference. This is followed by placing V3 electrode in between V1 & V4 . Then place the V5 electrode in between V4 & V6 on the anterior axillary line.

This is followed by placement of limb electrodes to develop a potential for electrical flow & maintain a vector based record of the leads I, II and III.Ref (fig. 2.6). The right hand electrode RA & left hand electrode LA can be placed on the hands or can be placed on torso also in case of amputee. The right & left leg electrodes are placed on either legs as a standard procedure.

The positions of the chest leads: note the fourth and fifth rib spaces

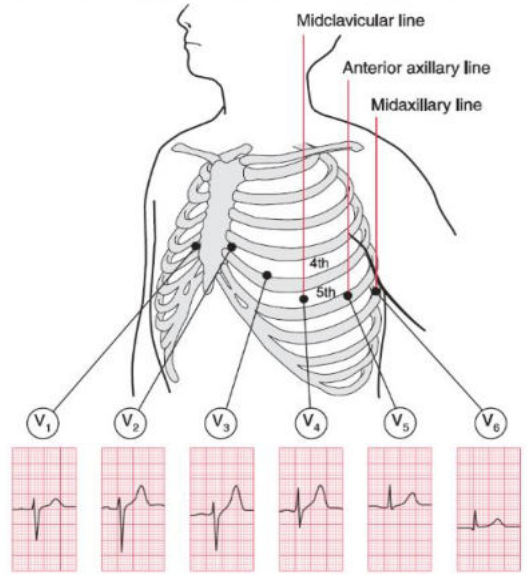


Fig.2.7

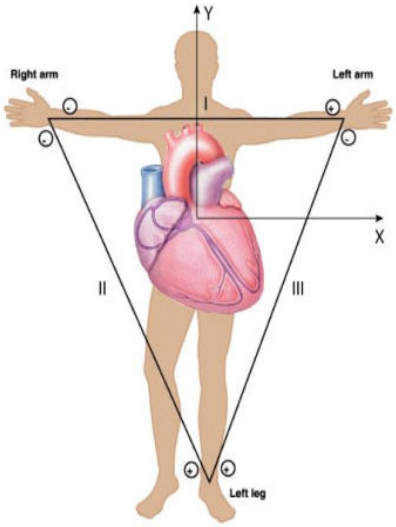


Fig. 2.6

The relationship between the 6 chest leads & the heart

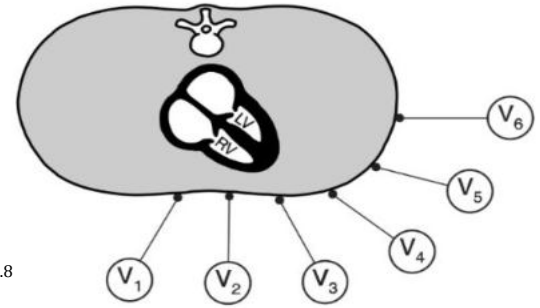
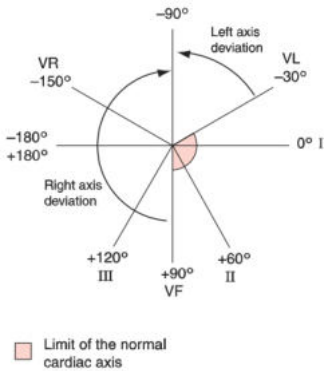


Fig.2.8

The cardiac axis and lead angles



The readings are then taken to obtain the electrocardiogram which is recorded & given to doctors & experts for further study & inferences.

Electrically, a lead is an electrical picture of the heart, but it is mistaken as a piece of wire that connect patient to the ECG Recorder.

The ECG recorder compares the electrical activity detected in the different electrodes, and the electrical picture so obtained is called a “lead”. The different comparisons ‘look at” the heart from different directions. For eg. When the recorder is set to “Lead I” it is comparing the electrical events detected by electrodes attached to the right & the left arms.

The basic objective of ECG recording is to observe the heart activity at particular locations on the chest through vector based directions along V1, V2, V3 , V4 , V5 & V6.aVL, aVR, and aVF gives the bigger picture from the vertical direction. The reading from limb electrodes is good enough to only know that the heart is working in case of cardiac arrest patients but the chest electrodes are used to understand the heart activity at a deeper level.

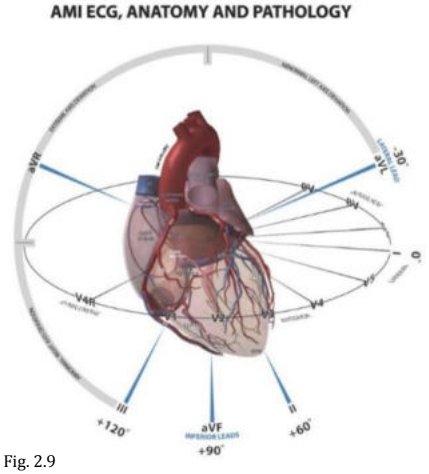
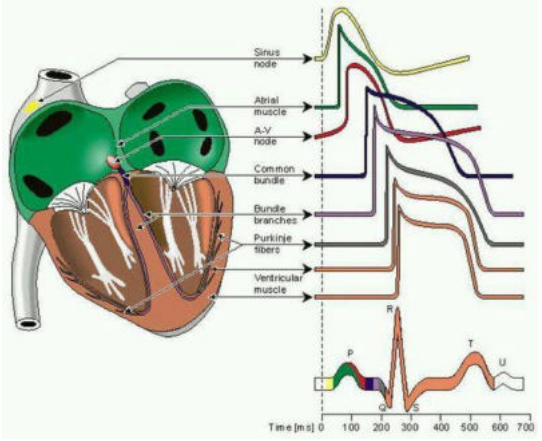


Fig. 2.9



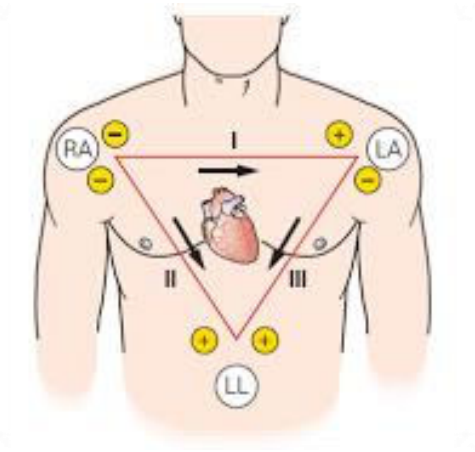


Fig. 2.10

Lead	Comparison of electrical activity
I	LA and RA
II	LL and RA
III	LL and LA
VR	RA and average of (LA + LL)
VL	LA and average of (RA + LL)
VF	LL and average of (LA + RA)
V_1	V_1 and average of (LA + RA + LL)
V_2	V_2 and average of (LA + RA + LL)
V_3	V_3 and average of (LA + RA + LL)
V_4	V_4 and average of (LA + RA + LL)
V_5	V_5 and average of (LA + RA + LL)
V_6	V_6 and average of (LA + RA + LL)

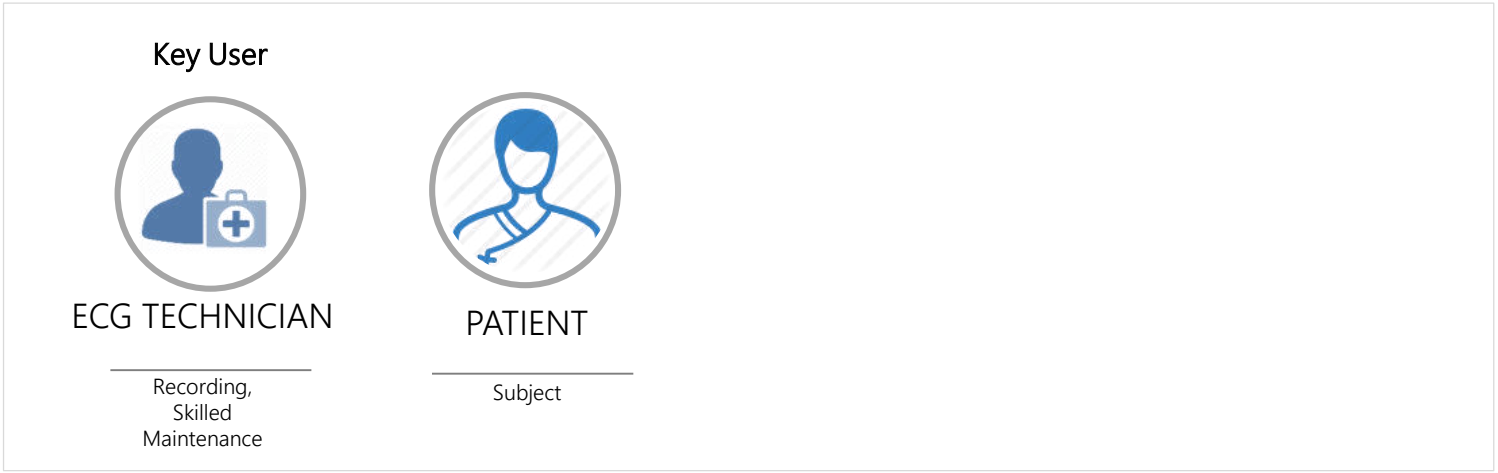
Key: LA, left arm; RA, right arm; LL, left leg.

Fig 2.11

2.2 Target Users

Identification of the target users

PRIMARY USER



SECONDARY USER

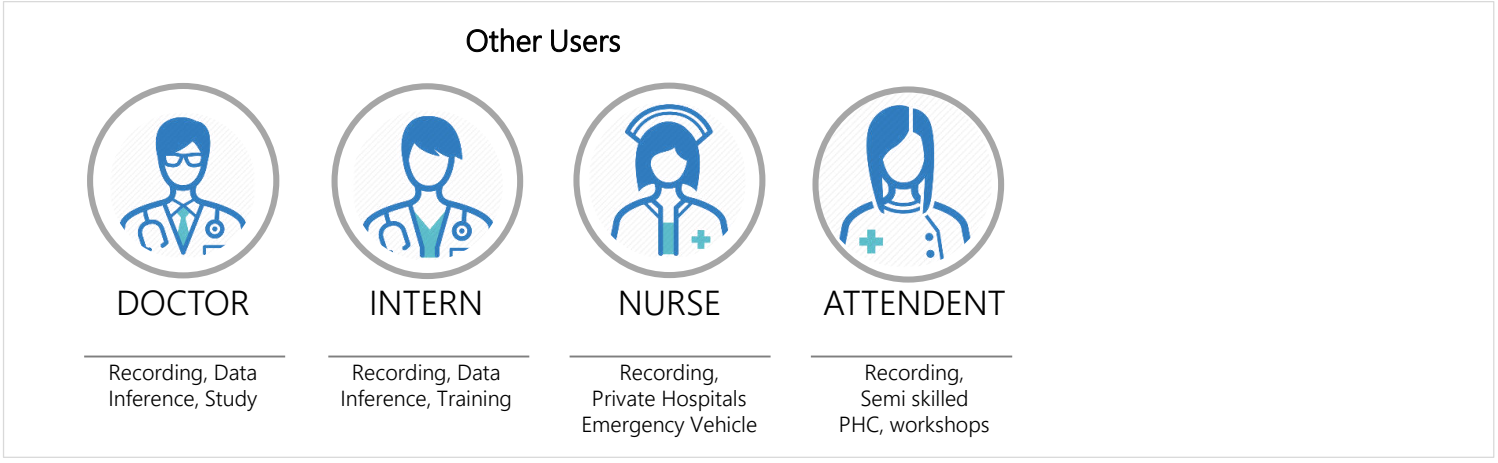


Fig 2.12 Source : Author

03

SECONDARY RESEARCH

3.1 Field Visit

3.1.1 Observations Scenario 1

Visit to Health ATM

Yolo Health ATM is a walk in Kiosk with integrated medical devices And is staffed by a medical attendant. It helps in getting a quick preventive health check up and helps in contacting reputed health Care providers with high definition video conferencing.

YOLO Health
Healthcare at Your Doorstep

A visit was conducted at the Health ATM Kiosk installed by YOLOhealth at Motilal Jaiswal Building in Prabhadevi, Mumbai & the process was recorded & documented.

Pic 3.1 Source: Author

3.1.2 Observations Scenario 2

Visit to Public Health Centre

As part of initial study, a visit was conducted at a Goa Medical College for observation of the various scenarios in which the ECG is monitored & recorded. Two days were spent in understanding the process, opinions of various staff including the doctors, Interns, ECG Technicians, nurses & the patients.

It was noticed that the process of recording the ECG varies with different sub scenarios wherein the whole recording set up changes as per the space, such as in the Casualty ward, OPD ward & the intensive care units.

Pic. 3.2 Source : Author

3.1.3 A day in life

An ECG technician who regularly diagnoses around 100 patients per day and having many years experience was interviewed.

Couple of hours were spent to understand the scenario in the OPD section of the health center where patients come for regular check up.

The process of ECG monitoring was observed and many questions were asked to the source person. The typical arrangement of things, the personal belongings, the arrangement of the system w.r.t. the patient were understood.

Pic 3.3 Source. : Author

A day in life

Pic. 3.4 Source : Author

3.2 Interviews

3.2.1 Key Users Scenario 1

As part of the field visit ,with the reference from BETIC Lab, YOLO Health ATM which has been set up in the Motilal Oswal Building , Prabhadevi was visited.

The Health ATM involves the regular check up of the employees of the firm , printing the report there itself with the online consultation of the employee and the patient with the concerned expert.

In case of ECG recording, they were recently testing the 4 lead clamp electrodes for the output.

The process of the health check up in the Health ATM was observed for many patients and the attendant was interviewed.

Mrs. Shreyans Gandhi,Co Founder
YOLO Health, Powai Plaza , Mumbai.

" We have currently developed a 4 lead ECG monitoring system with 4 clamp electrodes.

But, for a better & accurate recording of ECG, a 12 lead set up is preferred, wherein the chest electrodes need to be placed on patient .So, there is a need for a wearable kind of aid to support the existing 4 lead ECG recording system to make it 12 lead ECG system."

Pic 3.5 Image Source : www. Yolohealth.org

3.2.2 Key Users Scenario 2

As part of the field visit and data collection, visits were conducted to the two different hospitals, Goa Medical College, GMC and the IIT Hospital.

These were the comments about the existing ECG recording system in there. Various key users like the ECG Technicians, doctors, interns were interviewed & the process was photographed considering strictly as per maintaining the confidentiality about the identity of patient.

The ECG machine was used basically in 3 Sub scenarios

(i) Casuality
(ii) OPD
(iii) ICU (Intensive Care Unit)

All the processes in the Casuality & OPD were well observed & recorded to detail level while there were separate dedicated ECG panel mounted in ICU which were noted down.

Mrs. Vinda Joshi , ECG Technician, Casualty ward

" The ECG recording set up is user dependent and varies with the different handling habits of the different users.

Even the handling mostly depends upon the place where the ECG has been recorded. For example there is more rush in Casualty ward as compared to other regular check up wards.

Sometimes the process depends upon type of patients and even the frequency of patient input."

Dr. Manjunath Dessai, Senior Consulting Cardiologist, ICU, GMC

" We would be happy and would like to welcome the improvement in the existing set up which is time consuming & which can be less expensive ."

Mr. Fidelis Fernandes, Senior ECG Technician & instructor, OPD ward

" I have been instructing and handling the ECG set up since the last thirty years and I have to attend at least 100 to 150 patients per day in OPD. The process has been improved & better than the yesteryears , but there are still many shortcomings in the wire management of the set up which we try to manage with our own intervention ."

Dr. Deepika Chari, Junior Resident, Anasthaesia, OT, GMC

" The process of ECG recording is time consuming and it takes time to settle down with the entangled wires.

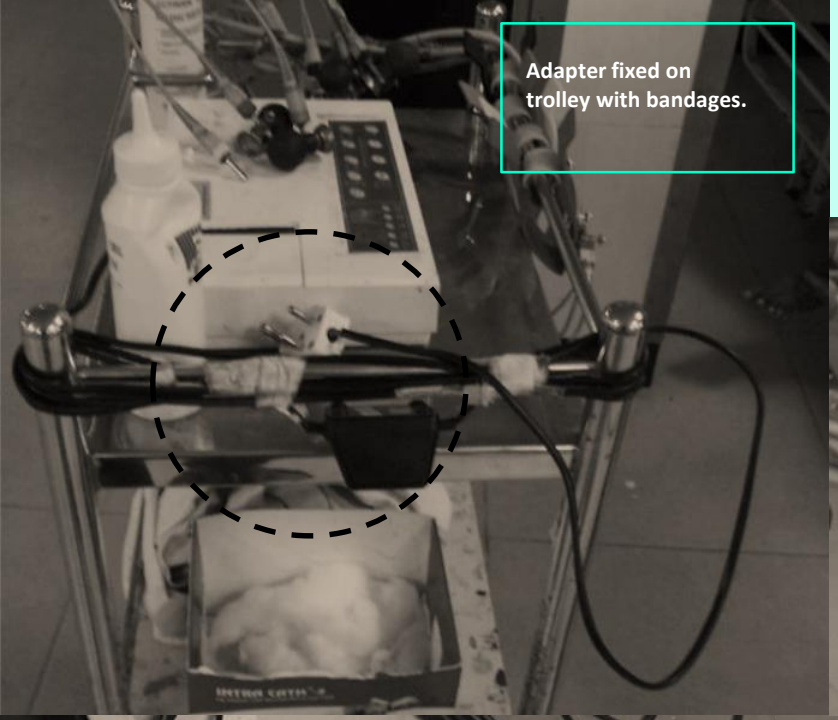
This sometimes hamper our other main activities and the process should be simplified ."

3.3 Key Findings

- The existing trolley has been used frequently in emergency conditions requires frequent maintenance and repair in terms of wire management & maneuverability.
- The messing up of wires is a big issue itself as visually dampens the working atmosphere & makes other peripheral activities complex.
- Considering the emergency situation, the ECG readings are to be taken at a faster speed.
- There is no height & trolley adjustment to make the set up suitable to all kinds of users.
- Electrode wire traffic is a big issue & wires are being channelized using bandages & tapes. There is no specific path for wires.

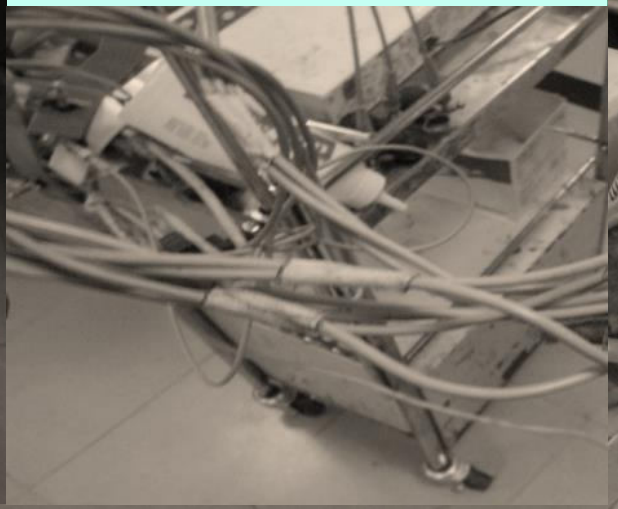
These pictures have been photographed in the Casualty Ward for a day and the process was monitored for various patients & different Key users.

System Related Issues

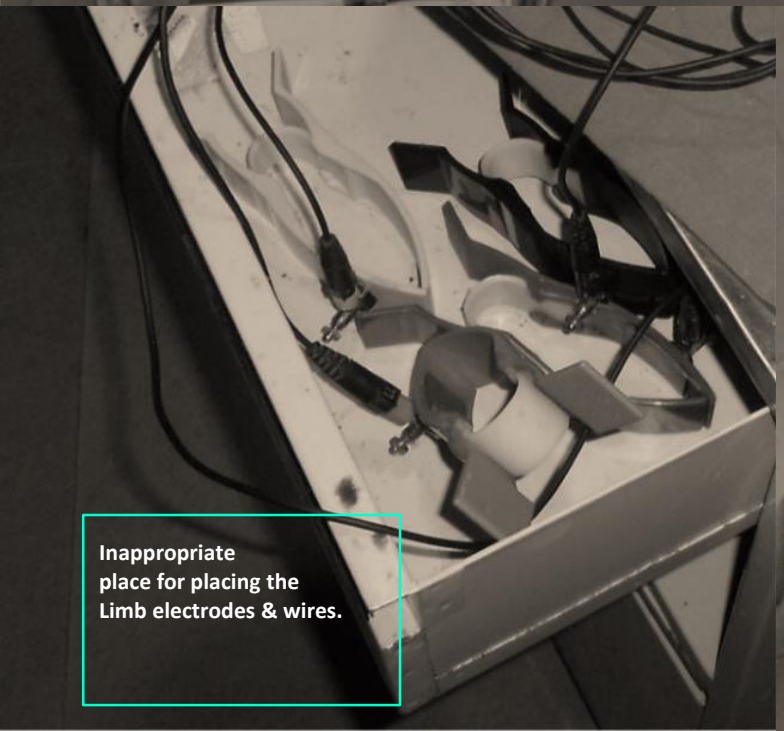


Adapter fixed on trolley with bandages.

Trolley needs to be moved hastily in case of emergency . Wheels get damaged



Mess in the Wire Traffic.



Inappropriate place for placing the Limb electrodes & wires.

Wires get damaged at the junction.

Cotton & jelly Gets clogged in The electrode cups.

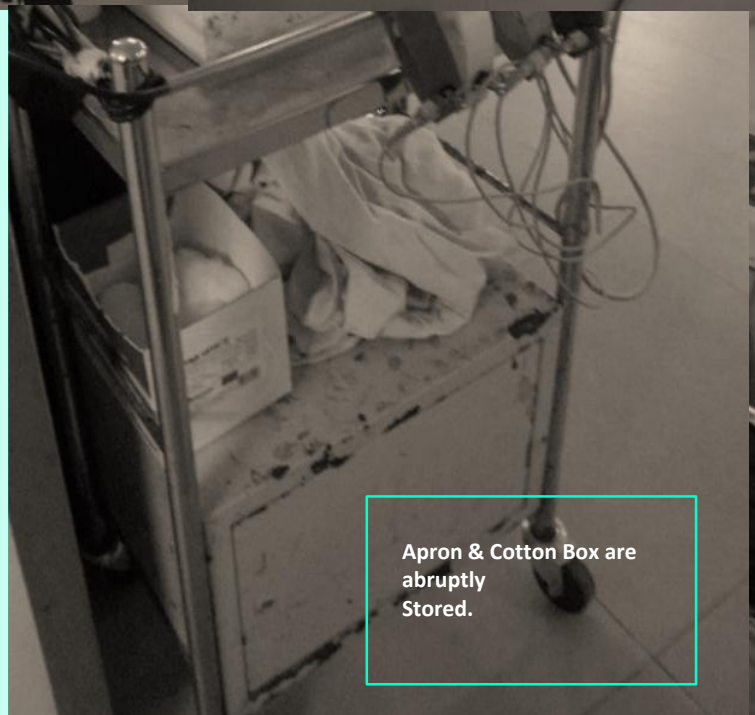
Other Issues

Hygiene Related Issues may include the frequent use of the same electrodes without regular cleaning & sterilization.

Cost of disposable electrodes is very high.

Sometimes the electro conductive gel gets sticky & gives irritating feeling.

Hanging Clamps



Apron & Cotton Box are abruptly Stored.

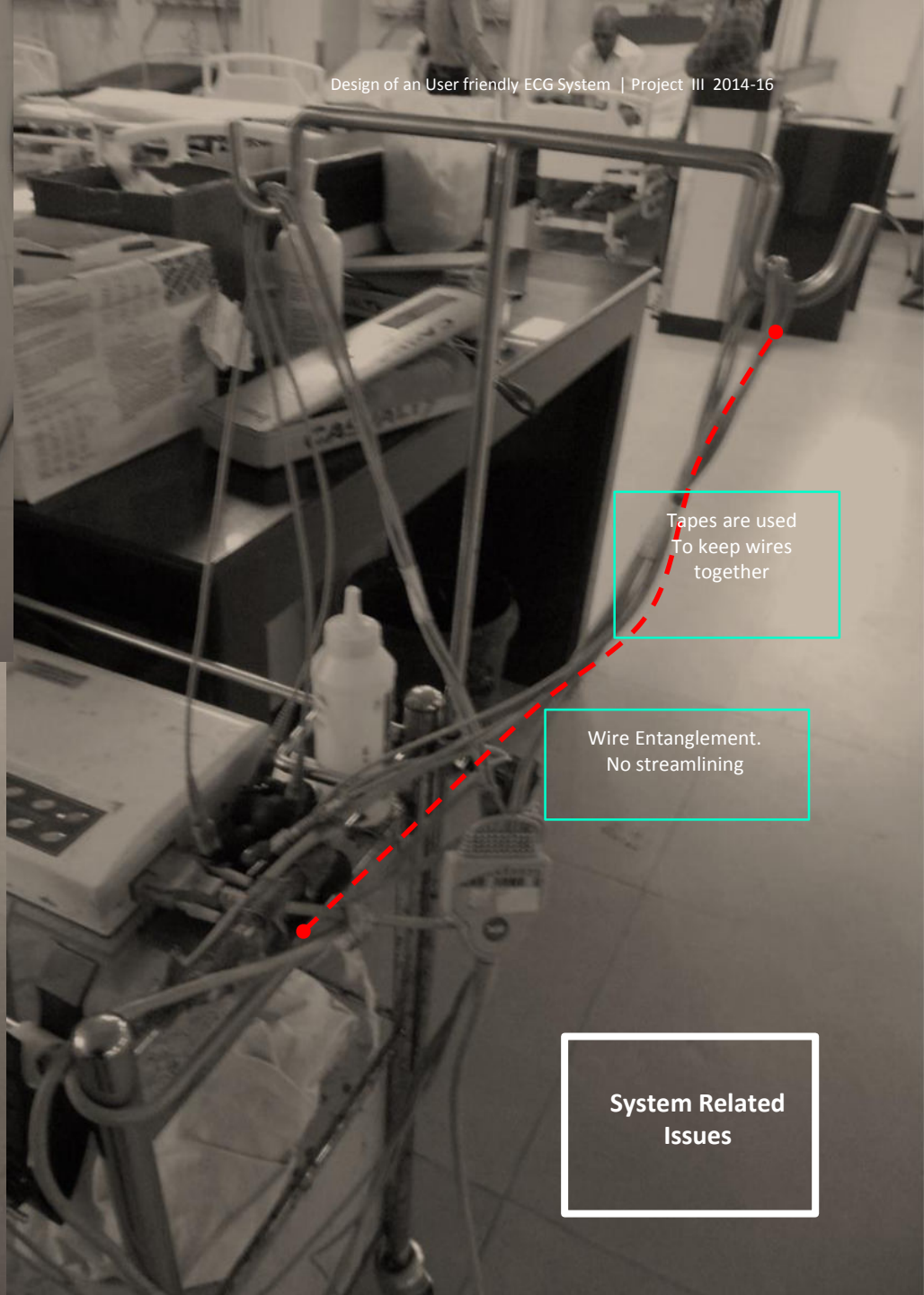
USERS

ECG Technicians

Doctors (Interns)

Nurses

Attendants



Tapes are used To keep wires together

Wire Entanglement. No streamlining

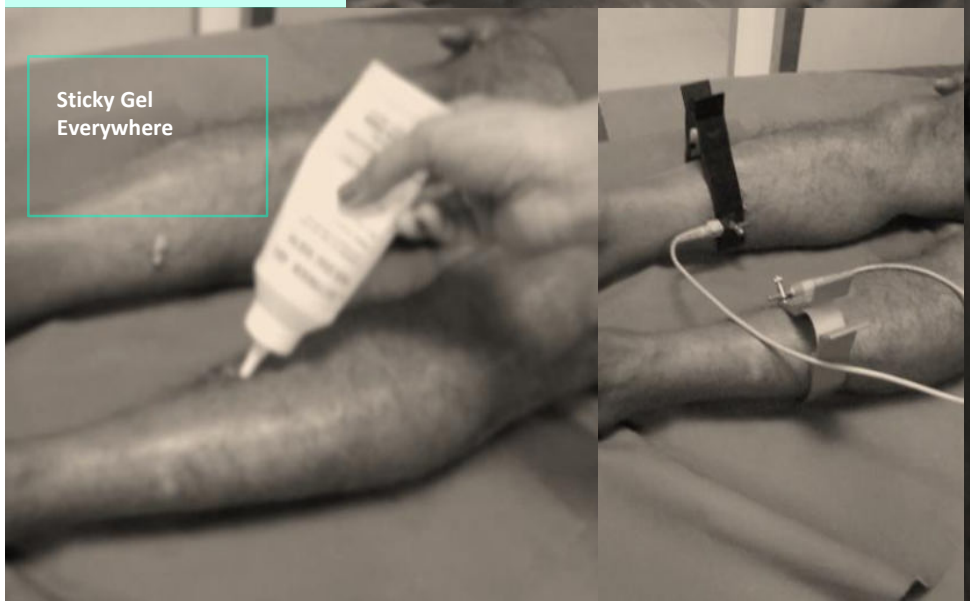
System Related Issues

3.3 Key Findings

- It is very difficult to control a restless patient & this affects the accuracy of the readings. For the ECG to be accurate the patient has to be stable. The ball cup electrodes breaks & comes out if there is disturbance.
- In case of emergency there is more movement of the staff and other members which makes the process cumbersome.
- The limb leads & hand lead wires get entangled every time .
- If the patient is hairy , then there is difficulty in placing electrodes.
- The major difficulty is in case of females with bigger breasts .It is difficult to locate the electrode positions.
- If the patient is having less muscles, then there is problem of adherence of electrodes.
- In case of children it is difficult to locate the electrodes.
- In case of HIV positive patients & patients with skin diseases , gloves are worn , but the electrodes are not cleaned regularly.
- Female patients have privacy issues.
- For larger feet (elephantiasis) , the limb electrode clamps break & require maintenance.
- Patients from remote places misinterpret the ECG process as shock treatment.

Patient Related Issues

The process is visually a mess for the user & can psychologically Bring down the morale of the patient.



Sticky Gel Everywhere

Gel spilled Around & on the Machine.

Patient Related Issues

3.3 Key Findings

Other Key problems

General procedure followed by ECG Technicians for location of electrodes on chest

First, the two electrodes V1 & V2 are placed considering the nipples as reference as Y- coordinates. Ref Fig.3.6

The distance between V1 & V2 can be around 5 to 8 cm.

Then electrode V4 is placed below the left nipple as reference as X-coordinate.

Electrode V6 is placed below the armpit level next.

Then electrodes V3 & V4 are placed in the intermediate spaces.

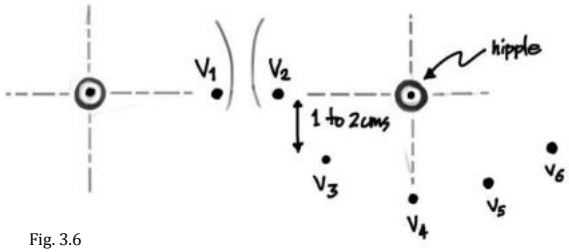


Fig. 3.6

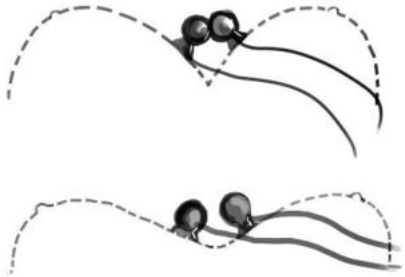


Fig. 3.8

In case of female patients due to the bigger breast tissue size, there is problem in accommodation of the cup electrodes. Ref Fig. 3.8They fall off and even it is difficult to locate position of electrodes & this results in wrong signals.

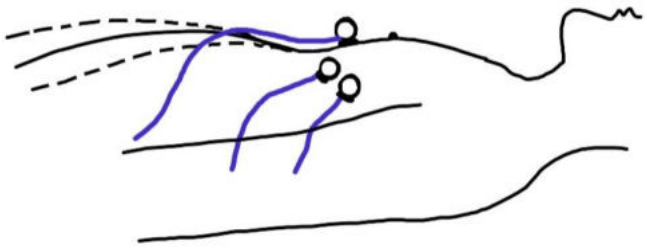


Fig. 3.7

Sometimes, the wires move on the body of the patient & this can create chances of infections in case of patients having Eczema & other skin diseases. Ref Fig. 3.7 Also, with more body movement during breathing there will be disturbance in the readings of the ECG graph which may result in anomalies.

Fig.3.9

In case of Hairy chest in male Patients, electrodes do not stick to the chest. They fall off.Ref Fig. 3.9

3.4 User Perspective

3.4.1 ECG Technician's perspective

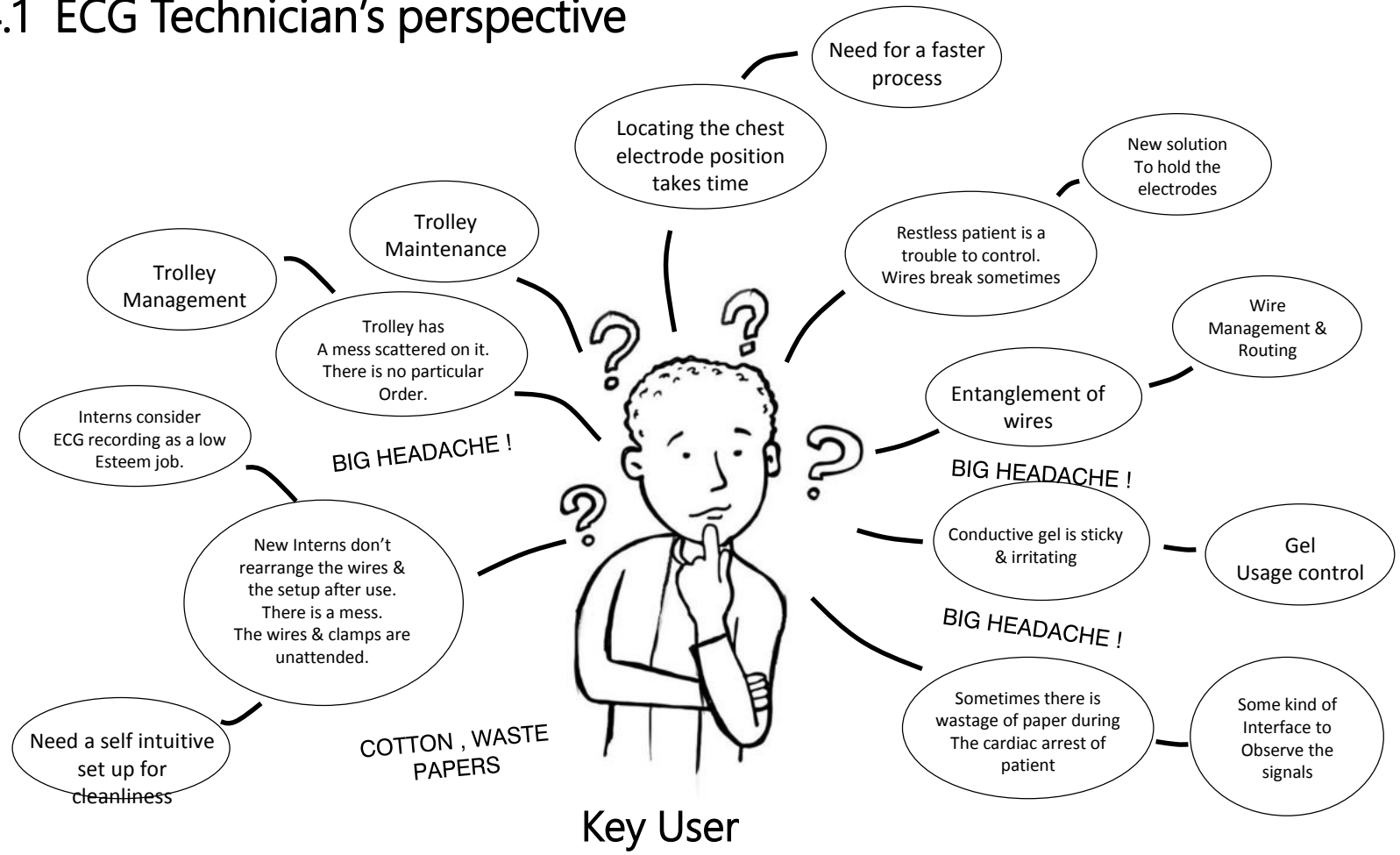
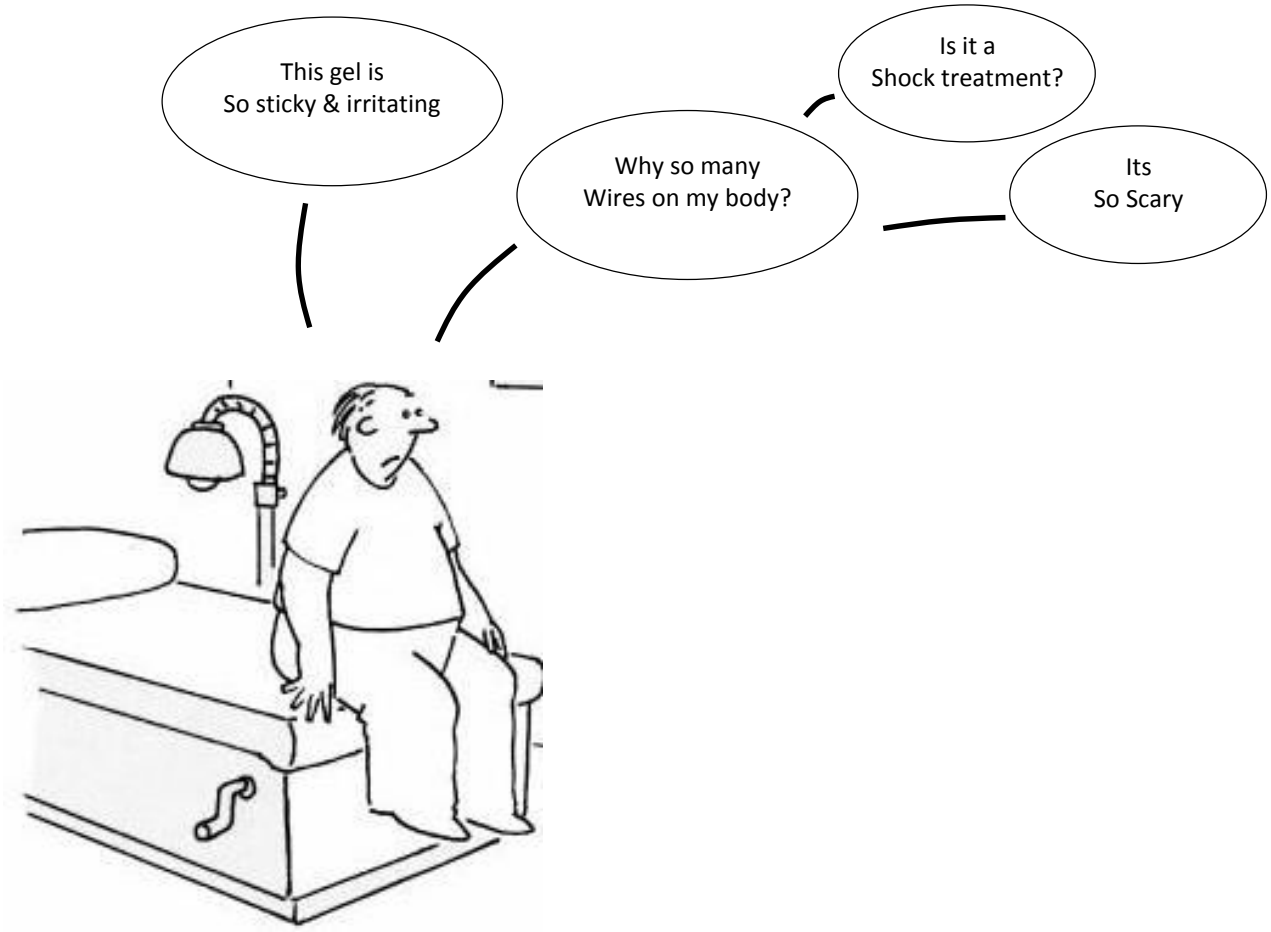


Fig. 3.10 Source: Author

3.4.2 Patient's perspective



Secondary User

Fig. 3.11 Source: Author

3.4.3 Design Student's perspective

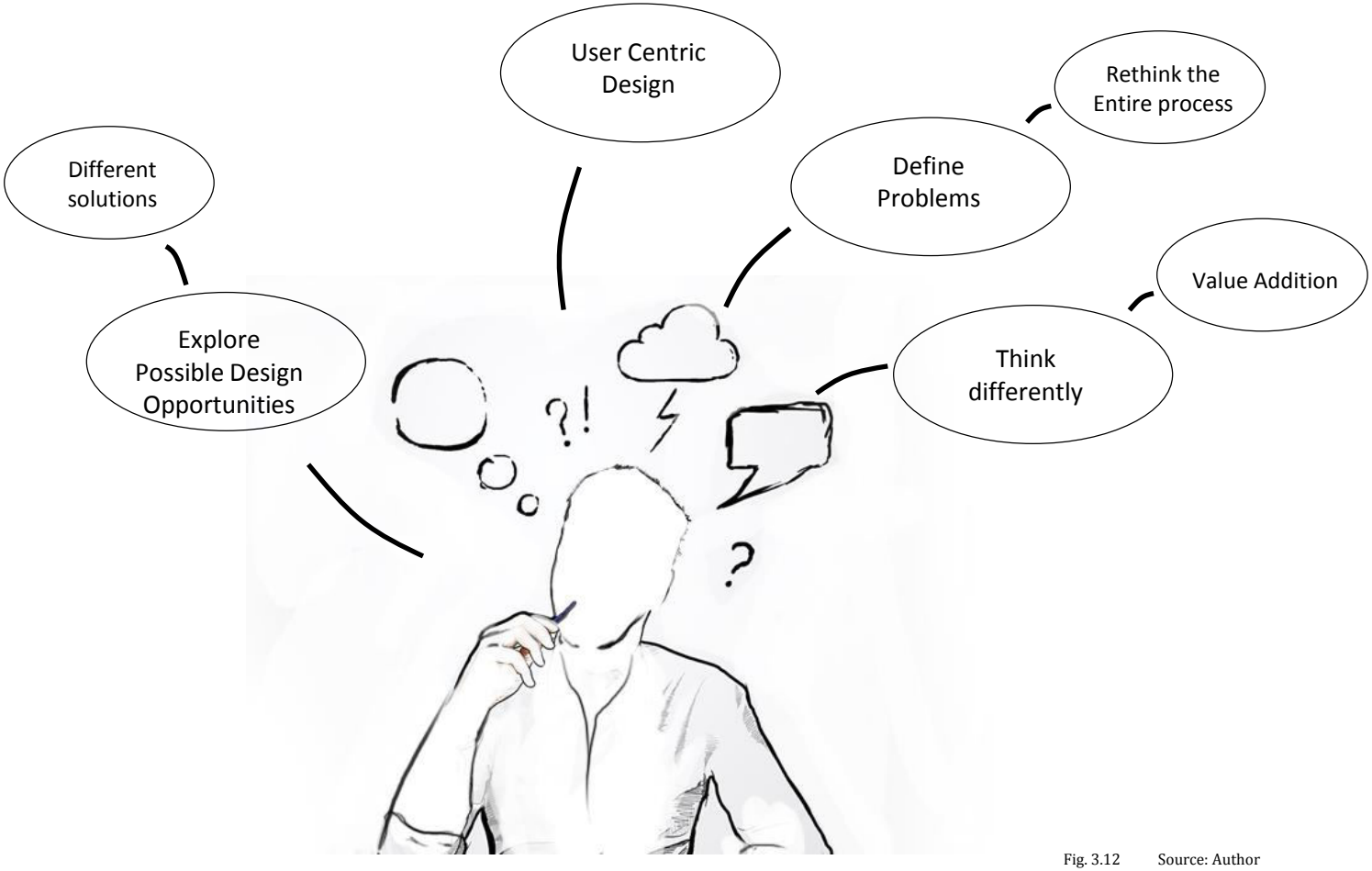


Fig. 3.12 Source: Author

3.5 Activity Analysis

3.5.1 Problem clustering & Collage

POST IT stickers were used to cluster the problems and chunk together to find out the major lacunae & issues at the system level.

Activity analysis for the process of ECG monitoring was done & the activities were detailed out considering the hand & eye movement of the Key user. The main objective is to understand the whole system at micro level & figure out the various shortcomings in the whole process. The various points were observed and noted down.

The hospital ECG Recording process was taken as the scenario for the process.

Pic. 3.13 Source : Author

Pic. 3.14 Source : Author

3.5.2 Micro level Activity Analysis of ECG recording

Patient	Patient enters the room	Patient shows the reference slip for ECG	The patient removes the dress to expose the chest area & lies down							
ECG TECHNICIAN	Take your position Check for the ECG machine & electrode wires position	Take the slip in your hand read it Check the physician order. Patient identification Check for the patient Info M/F or juvenile	Tell the patient to lie down in (supine) & take off the covering of dress to expose the chest area & expose the legs.	Observe the state & condition of the patient	See that the patient is in a relaxed condition	Locate the gel bottle from the table. Approach the bottle Pick up the bottle Skin preparation	Take the bottle near the patient Orient the tip of the bottle towards the right leg. Squeeze the bottle to make a gel spot on the right foot.	Locate the spot on the left foot Squeeze the bottle & orient the tip make a gel spot on the left foot.	Locate the chest lead locations on the chest. V1, V2, V3, V4, V5 & V6 respectively.	Squeeze & mark the gel spots in the locations of V1, V2, V3, V4, V5 & V6.
Locate & press the clamp electrodes on the limbs to release them from the hands & then the legs. First release the hand electrodes followed by the limb electrodes. Check for the wire entanglement	Once the readings are done, first remove the chest leads from the chest & place the leads respectively on the table or trolley (Casualty).	Approach the machine. Press the switch on manual mode for taking the readings. Take out the paper & check for any imbalance of readings. If imbalance is there, check for loose connections of leads & again take readings.	Locate V3(green) & V5 (brown) leads by holding the (green) in left hand & (brown) in the right hand. Press the cups to ensure to develop the vaccum for adhering. Check for the wire entanglement Check for the adherence of the knob ball on the Skin. Spread the gel on the skin. Check for loose connections for final check	Locate V4(blue) & V6 (black) leads by holding the (blue) in left hand & (black) in the right hand. Press the cups to ensure to develop the vaccum for adhering. Check for the wire entanglement	Locate V1(red) & V2 (yellow) leads by holding the (red) in left hand & (yellow) in the right hand. Press the cups to ensure to develop the vaccum for adhering. Check if the skin is hairy Check if the skin is dry (less muscles) If female, check if the leads are properly located on the bust area.	Apply pressure with thumb & fingers to open clamps . Place clamps in the respective left & right hands on the gel locations Check for the wire entanglement	Approach the table Locate the hand clamp electrodes pick up the RH (red) with left hand & the LH (yellow) with the right hand.	Apply pressure wit thumb & fingers to open up the clamps Place the clamps in the respective left & right limbs on the gel locations. Check for the wire entanglement	Approach table Locate Clamp electrodes Pick up the (red) RH electrode with left hand & the (green) LH electrode with the right hand. Use an alcohol pad to de- fat the skin and a dry cloth to gently abradethe top layers of the skin. This ensures the full contact of the elctrode with the skin for best conduction, but also can reduce noise and improve the quality of the recorded ECG.	Check whether the gel is properly squeezed & spread at the required location. Place the gel bottle back in its place.
		Patient gets up from the bed & alters his/her dress					The patient takes the reading & walks away			
Place the electrodes on the table & locate the box of cotton. Pull out some cotton to clean the gel spots on the skin.	Tell the patient to wipe the gel from the skin & get up from the bed.	Locate the pen on table , take the ecg graph reading & document the reading & submit the reading to the patient.	Check for the wire entanglement for the last time. Check for the gel & cotton clogging on the electrodes.	Write the patients name in the register	locate the hand sanitizing gel on the table.	Wash & clean your hands with the cleaning sanitizer.	Wipe your hands.			

CHEST LEAD PLACEMENT

- V1, 4th intercostal space (ICS)*, right sternal border
- V2, 4th ICS, left sternal border
- V3, equidistant between V2 and V4
- V4, 5th ICS, at the midclavicular line
- V5, at the horizontal level to V4, at the anterior axilliary line
- V6, at the horizontal level to V4 at the midaxillary line

Fig. 3.15 Source: Author

3.6 Market Study

3.6.1 Existing ECG Machines in market

A study on the current medical ECG recording devices was done & many features were explored. A study was done on which machines are more preferred in the Indian medical scenario Simultaneously the sizes and the dimensions of the machines were documented for further process.

It was observed that the brand of BPL ECG machines are highly preferred . Even the General Electrics limited have come up with the cost effective ECG machine which is also in demand. But they are not provided with process assisting peripherals which indicates a greater possibilities of design intervention.

Pic. 3.16 Source: Author

Image Reference:

http://www.ecgmachinesforsale.com/ge-marquette-ecg.html
http://www.hospiquip.net/ecg-machine.html
http://medfirstindia.com/ecg-machine-bpl-cardiart-9108.html

3.6.2 Existing ECG trolley available in market

The existing ECG trolley cart system in the market were googled and studied for the various parameters like set up, optimum working height. The images were chunked together as per features and observations were recorded.

The observed trolley during the field visit in scenario 2 was not well organized and this indicates the possibility of a design opportunity in this situation to develop an user friendly trolley set up for the key user.

Pic. 3.17

Image Reference:

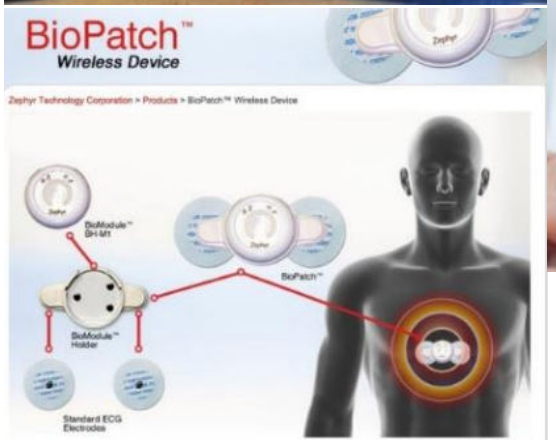
Reference- https://www.medshop.com.au/diagnostic-equipment/ecg-monitors
http://www.quickmedical.com/schiller-diagnostics-mobile-ecg-ekg-carts-stands.html
https://www.henryschein.com/us-en/medical/services/ch_welchallyn.aspx

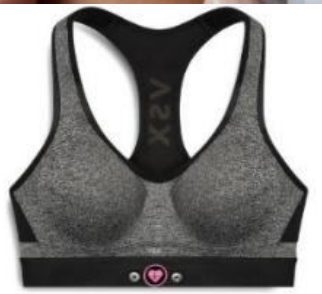
3.6.3 Wearable devices for ECG Monitoring & Recording

The existing ECG trolley cart system in the market were googled and studied for the various parameters like set up, optimum working height. The images were chunked together as per features and observations were recorded.

The observed trolley during the field visit in scenario 2 was not well organized and this indicates the possibility of a design opportunity in this situation to develop an user friendly trolley set up for the key user.

Biopatch by ZEPHYR U.S. based company in health & monitoring conditioning.





Pic. 3.18

Image Reference:

Other Brands include LIFEBEAM Products, MIO ALPHA2, Garmin Soft Strap HRM- TR1, Wahoo Fitness ticker X, AIQ Hexoskin, Athos biometric smartclothes, LYCOS life wearable band.

Reference- http://www.zephyr-technology.nl/en/product/77/biopatch.html, www.wearable-technologies.com

3.6.4 Type of ECG recording electrodes in the market

The study was conducted and opinions from the experts were taken regarding the existing ECG recording electrodes in the market.

Following are the available electrodes in the market.

- Dry Electrodes
- Ag- AgCL electrodes
- Ag coated electrodes
- Stainless Steel Electrodes

Wet electrodes and Dry Electrodes

Wet electrodes— single use/disposable
Require adhesives
Time consuming don/doff procedures
Limited shelf life
Requires professional assistance.

Dry electrodes— Require appropriate placement
Strong adhesion for accuracy in reading of signals

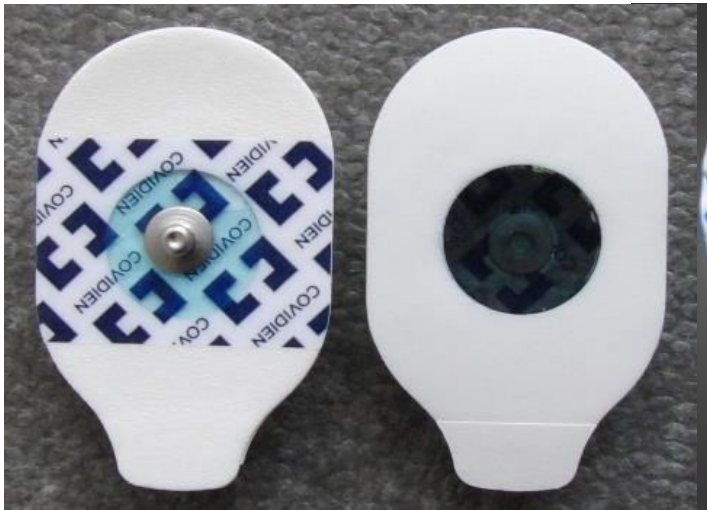


Image Reference: Pic. 3.19

http://orbitalresearch.com/Medical/index.html
http://www.indiamart.com/medico-electrodes-international/
http://www.medicoelectrodes.com/
http://www.muslim-medical.com/ecg/
http://www.henleysmed.com/product/h135sg-kendall-ecg-electrode-43-x-35mm-stud-adaptor

04

THE DESIGN PROCESS

4.1 Design Brief

To design and conceptualize a medical grade , 12 lead aid & develop an user friendly ECG recording system considering the user centric approach of design.

Design Scenarios

12 lead ECG recording in a Health ATM Kiosk or OPD room in Public Health Centre set up with less assistance.

Design Requirement

Design Requires to develop a “one size fit all” aid & making ECG recording an user friendly & less hectic process.

Goals to be set

- Understand user profile & environment of use
- Provides accurate electrode placement
- Comfortable, simple
- Economical (Cost Effective)
- Reusable aid
- Light weight, Portable
- Medical Grade ECG recording.

Challenge

- 12 Lead ECG configuration requires accurate electrode placements.
- Varying body sizes with respect to age and gender.
- The device placement
- ECG process preparation
- Cable Management

Pic. 4.1 Source: Author

4.2 Mind Mapping

4.2.1 Mind mapping the scenario problems

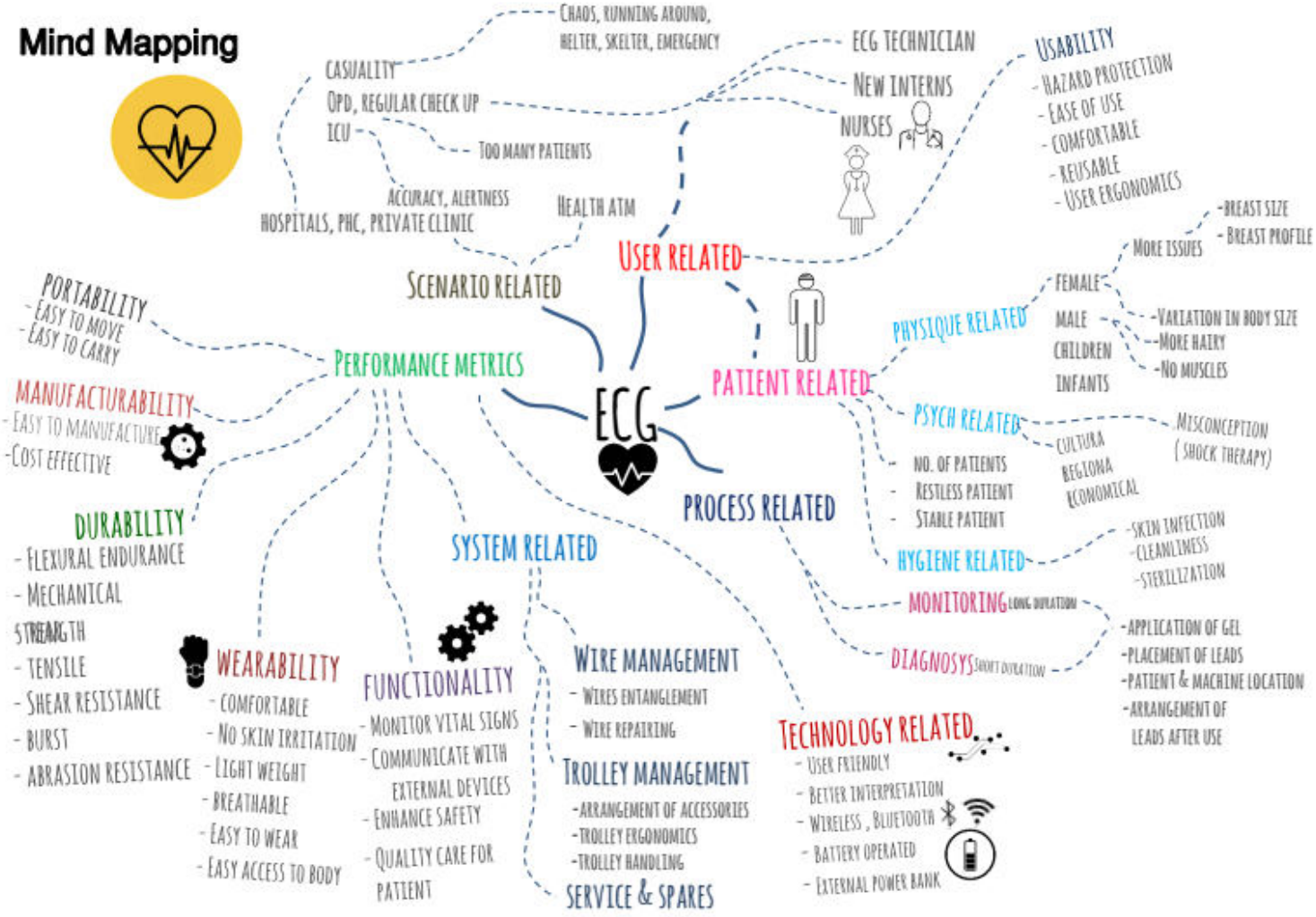


Fig. 4.2 Source: Author

4.2.2 Selection of Design Approach

Two different scenarios & two Different environments

Selection of the two approaches , Health ATM Kiosk and Public Health Centre, both have different scenarios and factors which may help advance the concepts in different directions.

So, at first the Health ATM Kiosk was considered as a Approach 1 wherein the ideations were started to come up to a conceptual level in deriving to a possible logical solution.

In the other approach , Public Health Centre, the methodology works out at a system level in a broader sense. The data collection will carry a very pivotal role in generating the concepts for both the approaches.

Pic.4.3 Source : Author

05

APPROACH 1 - HEALTH KIOSK

5.1 Mind Map

5.1.1 The scenario Health Kiosk

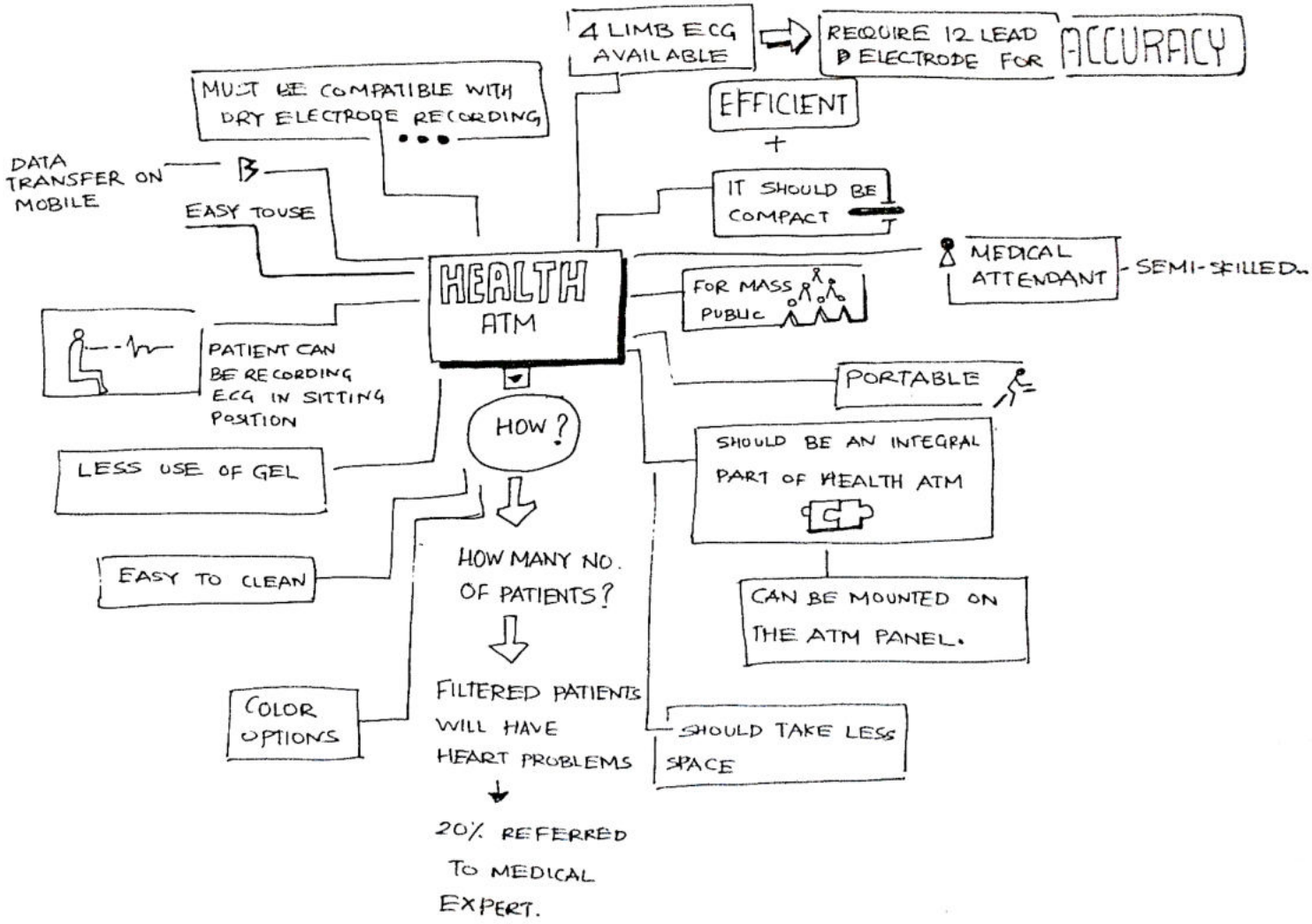


Fig. 5.1 Source: Author

DREAM

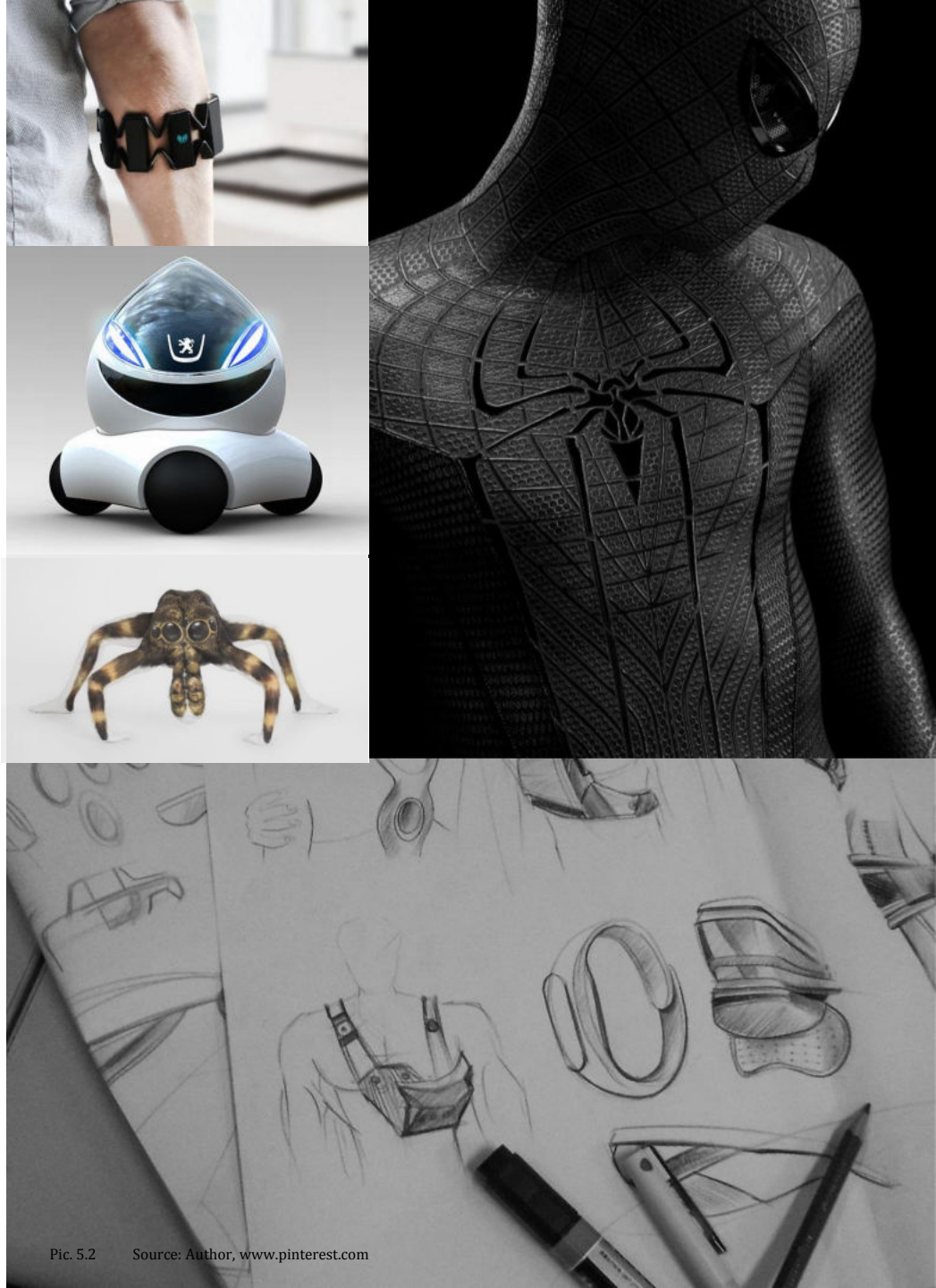
5.2 Early Ideations

A fascination towards the fantasy world helped to come up with initial ideas which were whirling around the mind. Even the reading the patent reviews helped to come up with different ideas.

The main intention of the ideations were to come up with something radically different in order to reduce the wire mess & entanglement of the wire as there might be more number of footfalls of patients or general public in an health ATM or Kiosk.

The use of stretchable material and fabric could be possibly some direction to make the aid wearable over the body itself.

At first, some preliminary sketches were sketched to bring out the ideas on paper and then further developing those concepts.



Pic. 5.2 Source: Author, www.pinterest.com

Some concepts included the gadget consisting of the six chest electrodes to be accommodated on the single unit which could be worn by the patient even in sitting position in a Health Kiosk environment.

It could be a something which can be worn on the chest with a compact unit recording the signals and then transmitting the signals to the server unit via Bluetooth or ZIGBEE connectivity. Ref Fig. 5.3

It can be even a retractable flexible material strip which retracts out of an unit and which helps in locating the chest electrode . Ref Fig. 5.4

There can be even a possibility of U – Clamps to locate the kit under the armpit & then further locating the kit with shoulder bands. Ref Fig. 5.5

Fig. 5.3

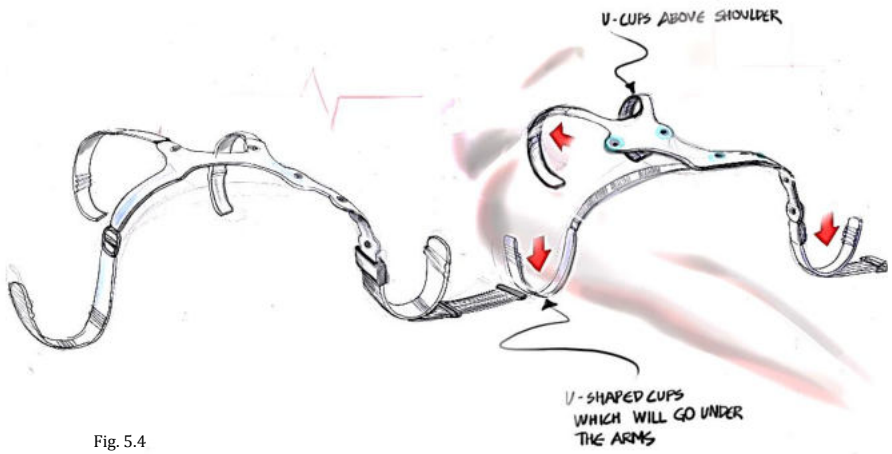


Fig. 5.4

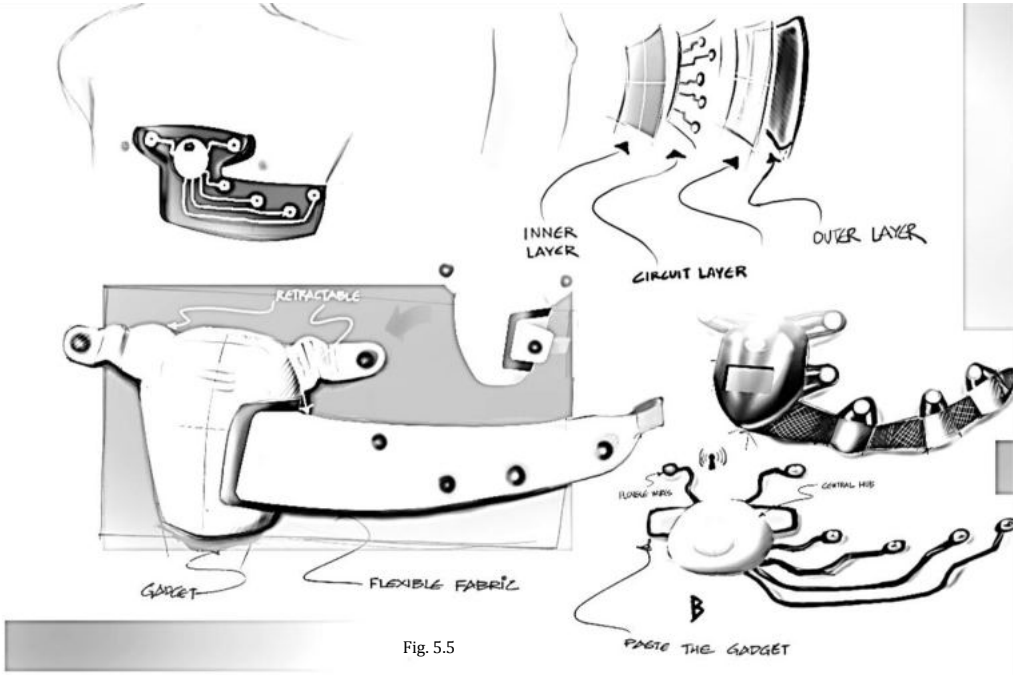


Fig. 5.5

5.3 Implementation of Bionics principles

5.3.1 Understanding bionics of various insects

Biomimicryis the imitation of models, systems, elements from nature used for solving human problems. The designers can actually apply the principles to solve many problems.

An observation of nature and its structures helps to give useful information for human applications. In this case, elements from nature were explored and certain insects and their characteristics were studied to derive at some design solution.

The features that were to be abstracted were minutely observed & tried to get the best possible function out of it to develop a concept.

The bionic specimen selected here was a lobster which has its unique characteristics of a shell which has equal interval of features and surretions marked on its body.Consider a lobster is sitting on your chest and it is spreading its tentacles out to measure your ECG at accurate points.It can adjust its body as per the size of the chest which can become an inspiration to derive at some useful hint.Even, initially the octopus was considered with its fluidic & more flexible form to act as source for inspiration.

Pic. 5.6

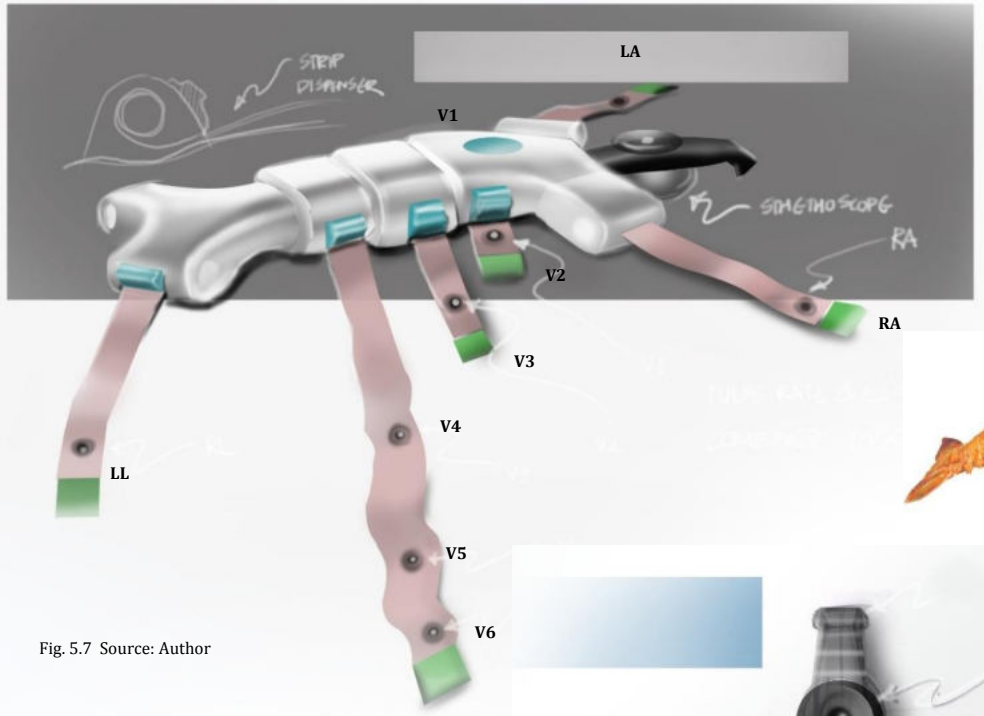


Fig. 5.7 Source: Author

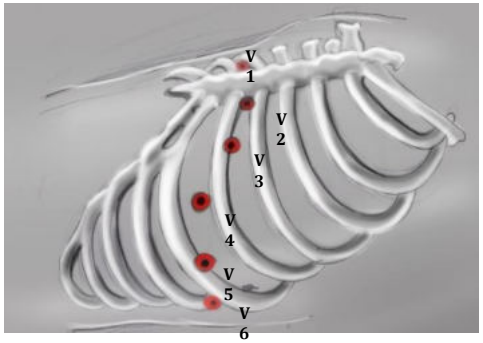


Fig. 5.8 Source: Author

Considering the characteristics of a lobster, the concept speaks about the shape characteristics of a lobster as a compact unit which when placed on the chest records the data at the centralized hub.

The hub has a jaw bone gap detecting marker which is flexible. There is a vacuum suction cup which then fixes the device on the chest & which acts as a stethoscope recorder for the pulse rate with both the ECG & pulse rate parameters combined together.

The unit can be flexible along the y axis also. The electro conductive ink printed flexible strips retracts out (the concept derived from retract actable measuring tape) which once located can be locked with slide buttons.

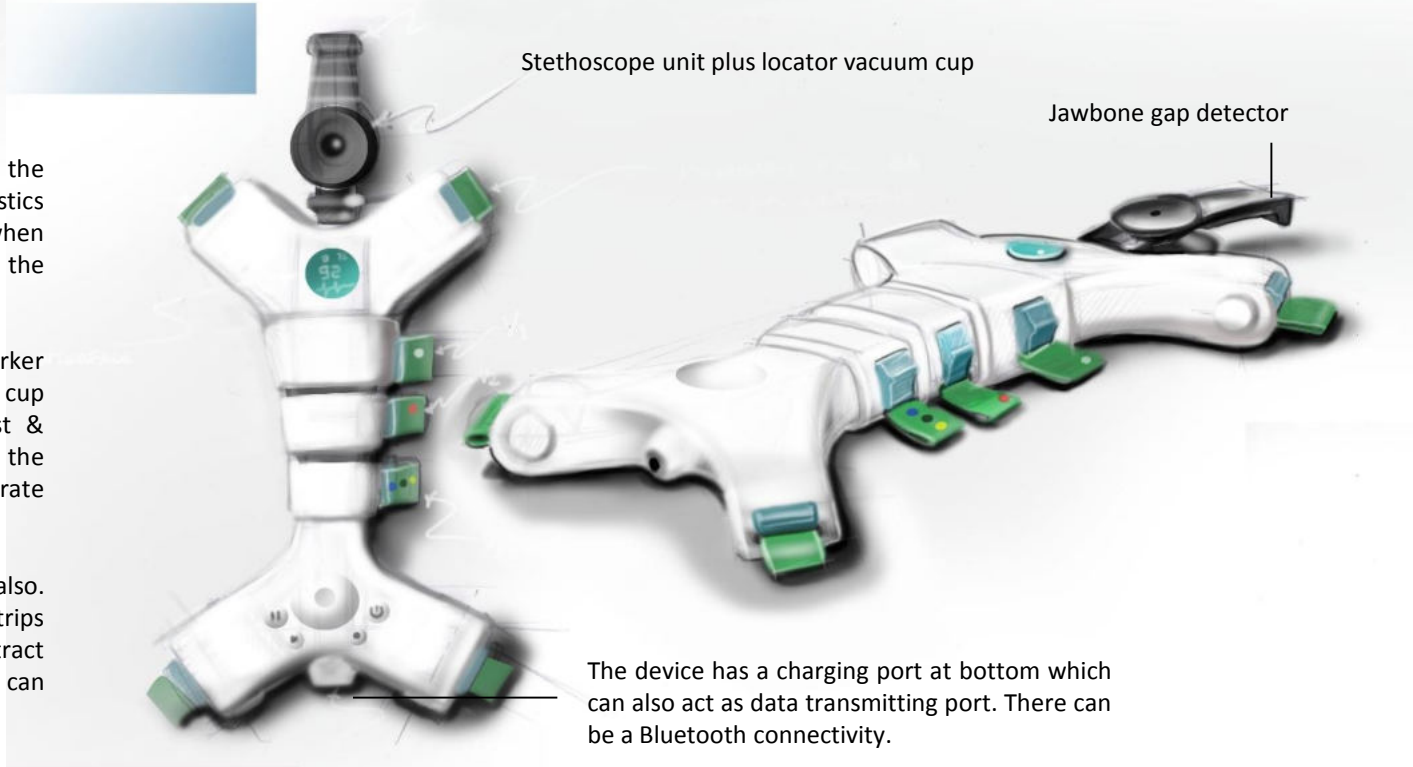


Fig. 5.9 Source: Author

There can be another variation of the unit with the structure acting as a telescopic unit to adjust the length along the chest y axis.Ref. Fig 5.10

The flexible retractable printed film comes out of the unit like a film roll from a camera.

The unit can be a hanging unit ref fig.5.11 Which can be hanged on a strap which moves around the neck and acts as RA and LA electrode unit which has two fixing points with the chest unit being mounted on it.

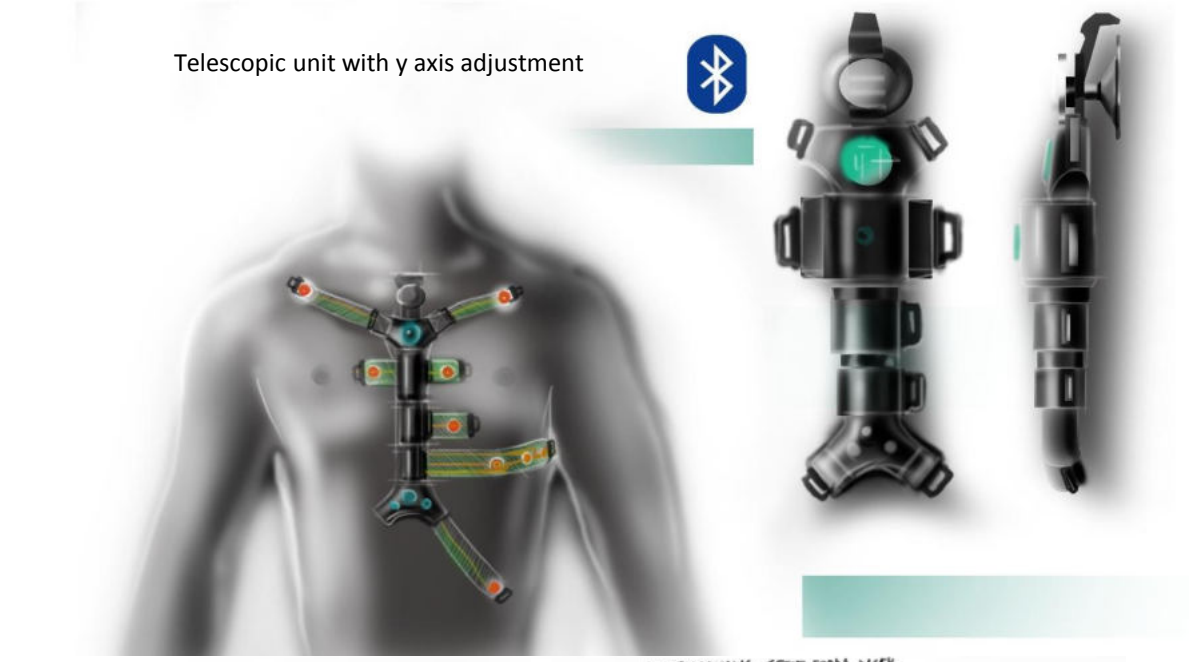


Fig. 5.10

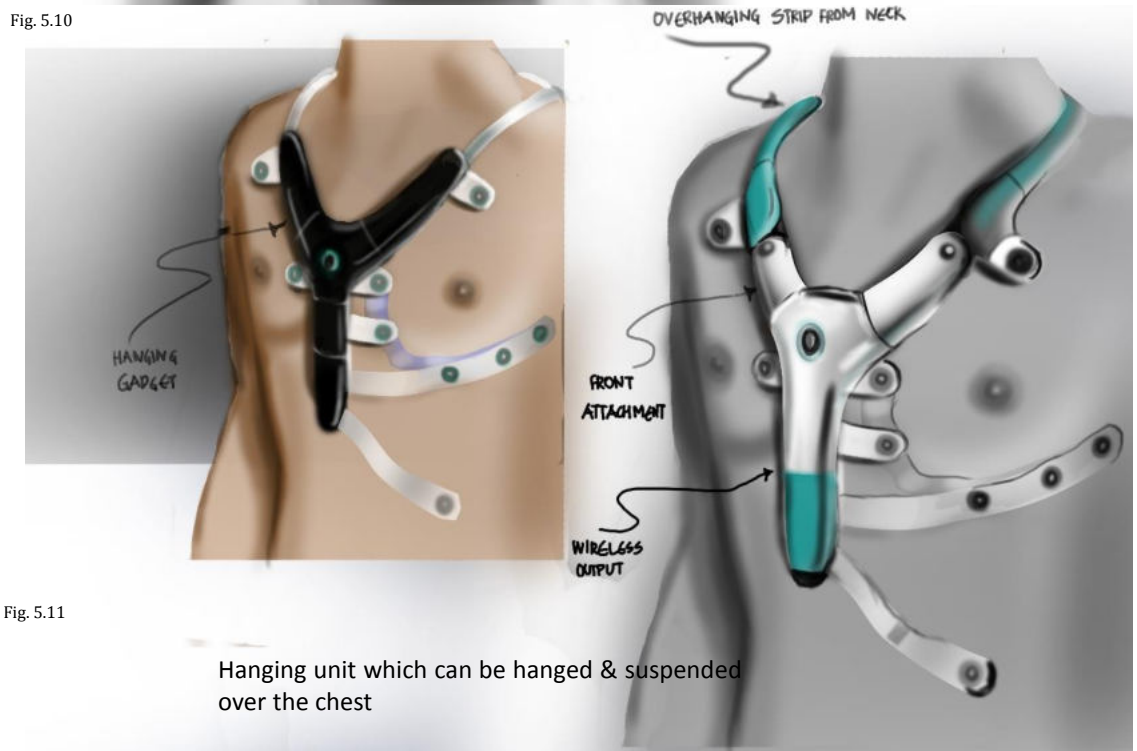
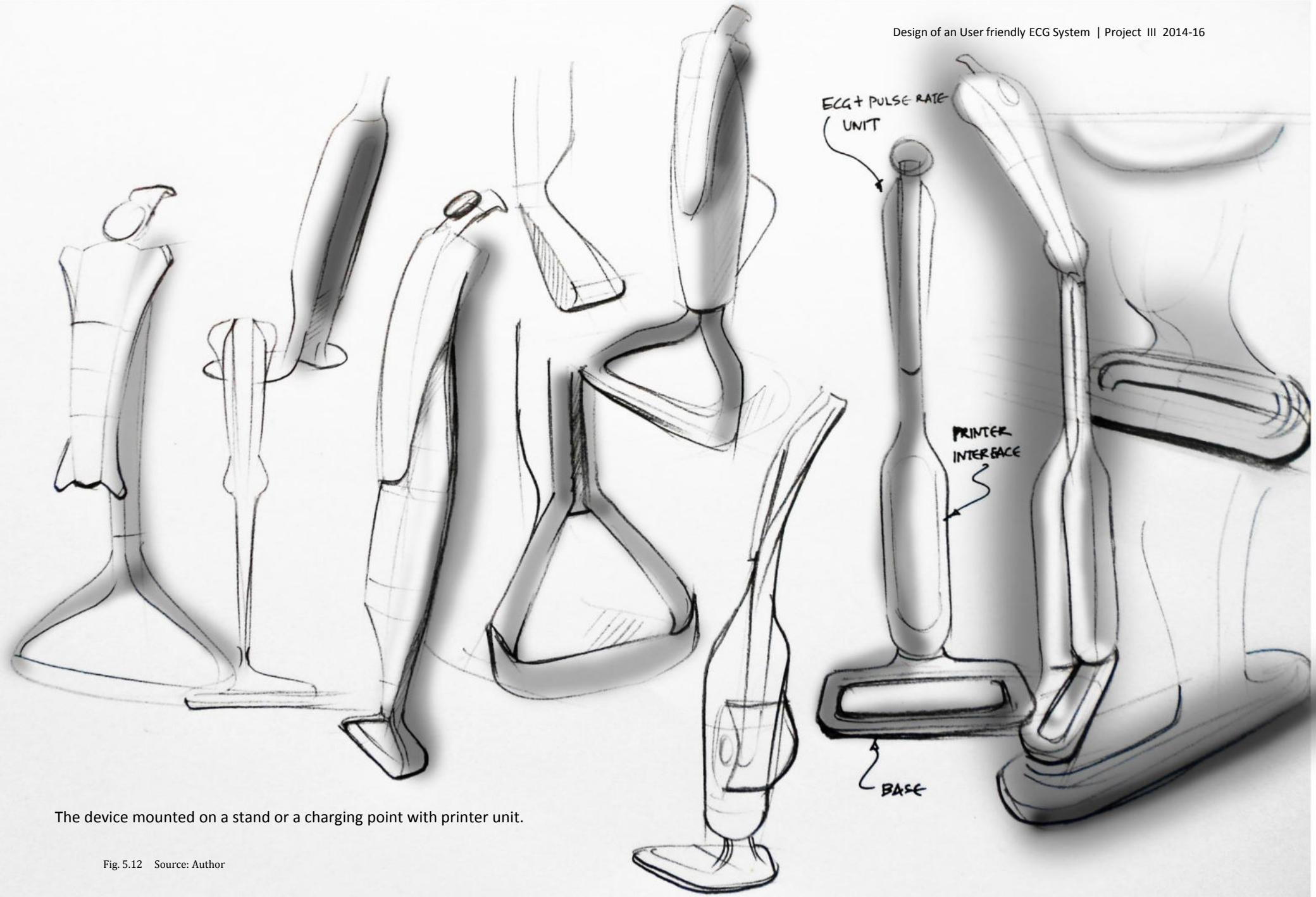


Fig. 5.11

Hanging unit which can be hanged & suspended over the chest



The device mounted on a stand or a charging point with printer unit.

Fig. 5.12 Source: Author

The device after use can be mounted on a single unit consisting of a stand and a printer unit. The device can act as very compact unit for portability and storage.

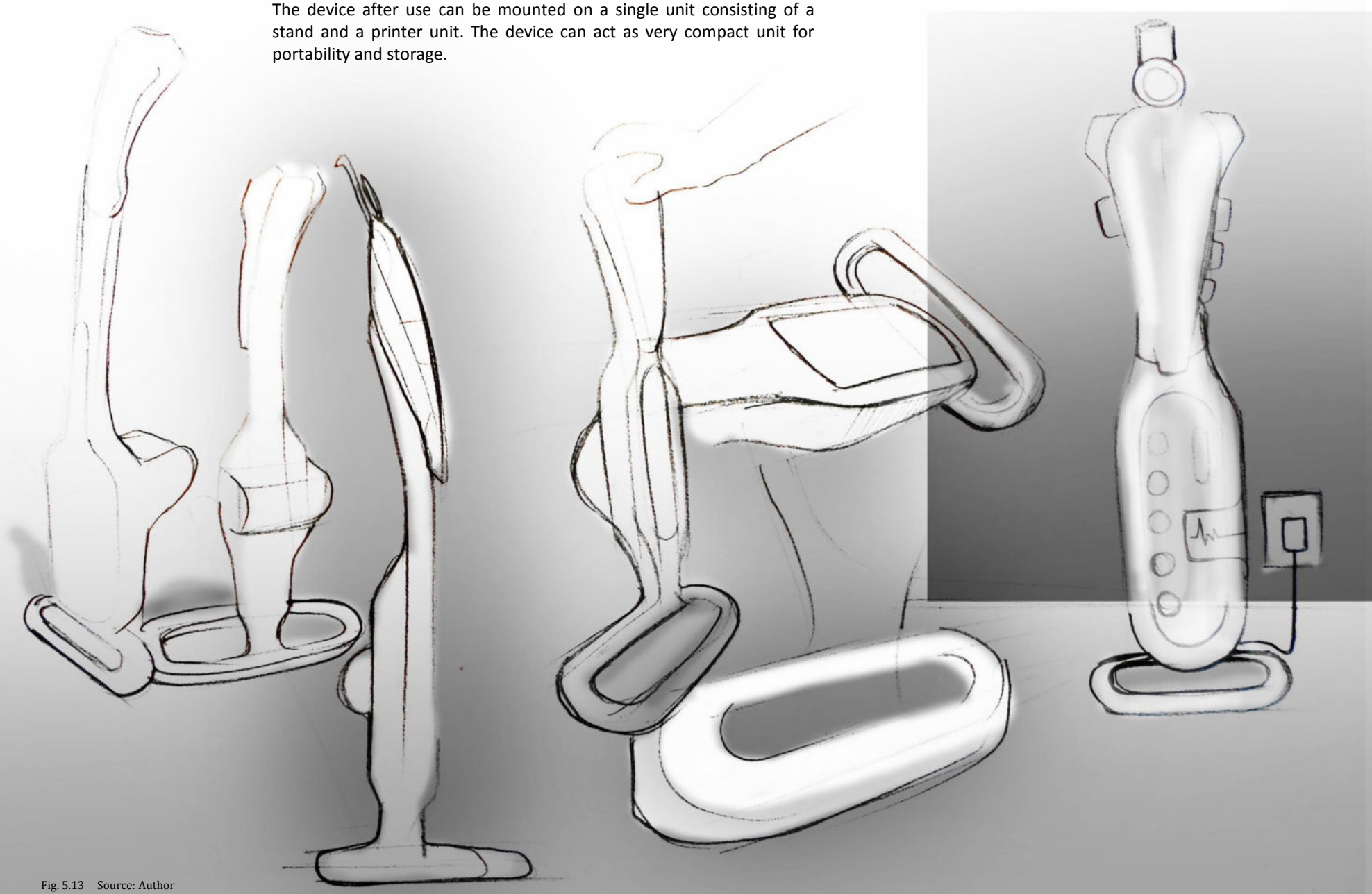


Fig. 5.13 Source: Author

5.4 Conclusion

5.4.1 Further Insights

Remark for the concept

This concept which is right now at a conceptual level can be further taken for further research & development.

The main objective of removing the mess of wire entanglement and the Health Kiosk related scenario requirements can be foreseen with this approach for future studies.

The final integration of the principles of bionics with the development of gadget can hold the major stokehold in the efficient ECG & pulse rate monitoring.

It may be kindly noted that this concept was kept at conceptual level touching the superficial aspects & further concentration was moved on Design approach 2 for Public Health Kiosk.

06

SCENARIO 2 - PUBLIC HEALTH CENTRE

5.1 Mind Mapping the Scenario problems

6.1.1 Mind mapping the System Level

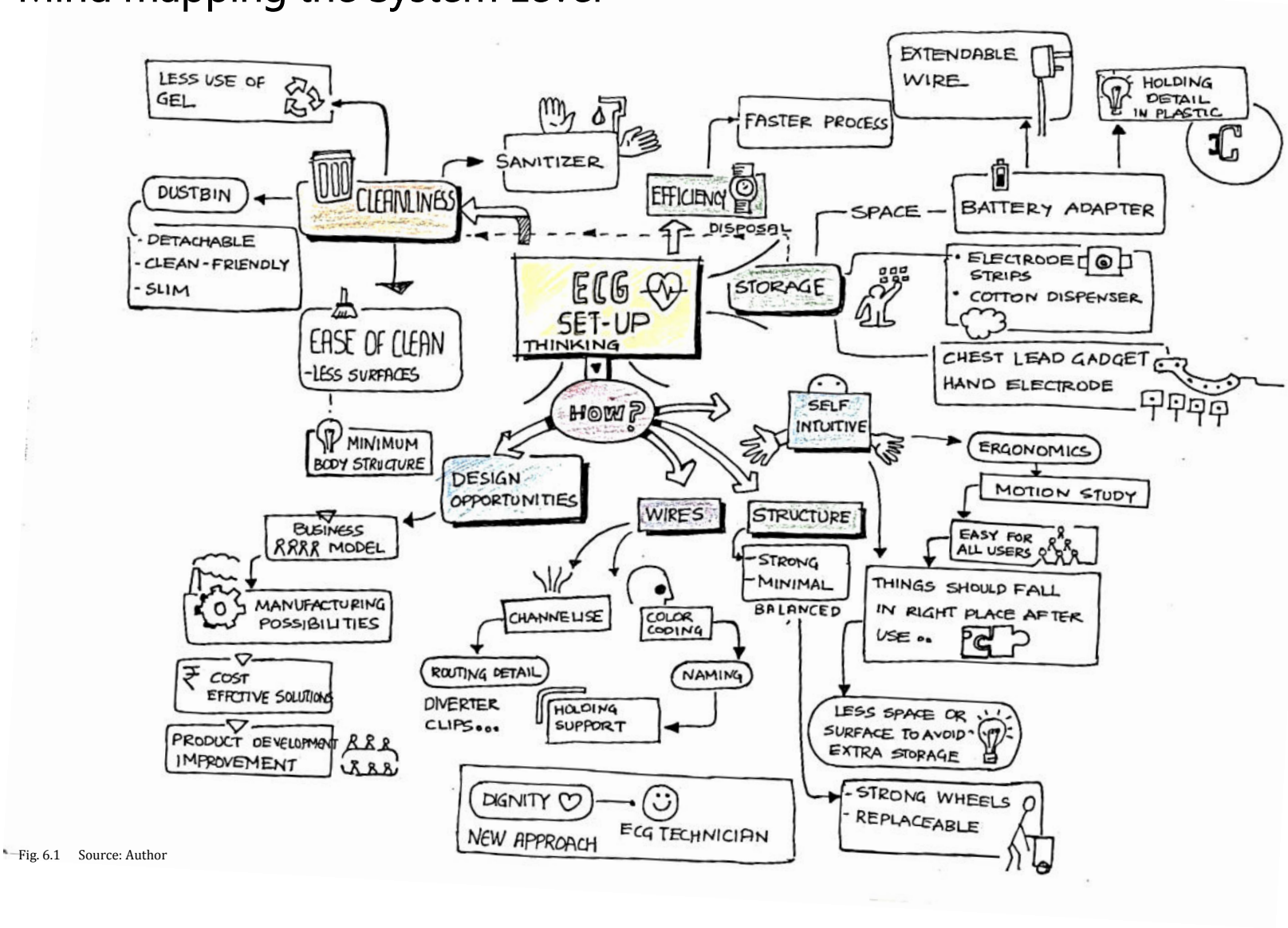


Fig. 6.1 Source: Author

07

DESIGN OF PRIMARY COMPONENTS

7.1 Design Solution for controlling ECG gel

7.1.1 Brain storming

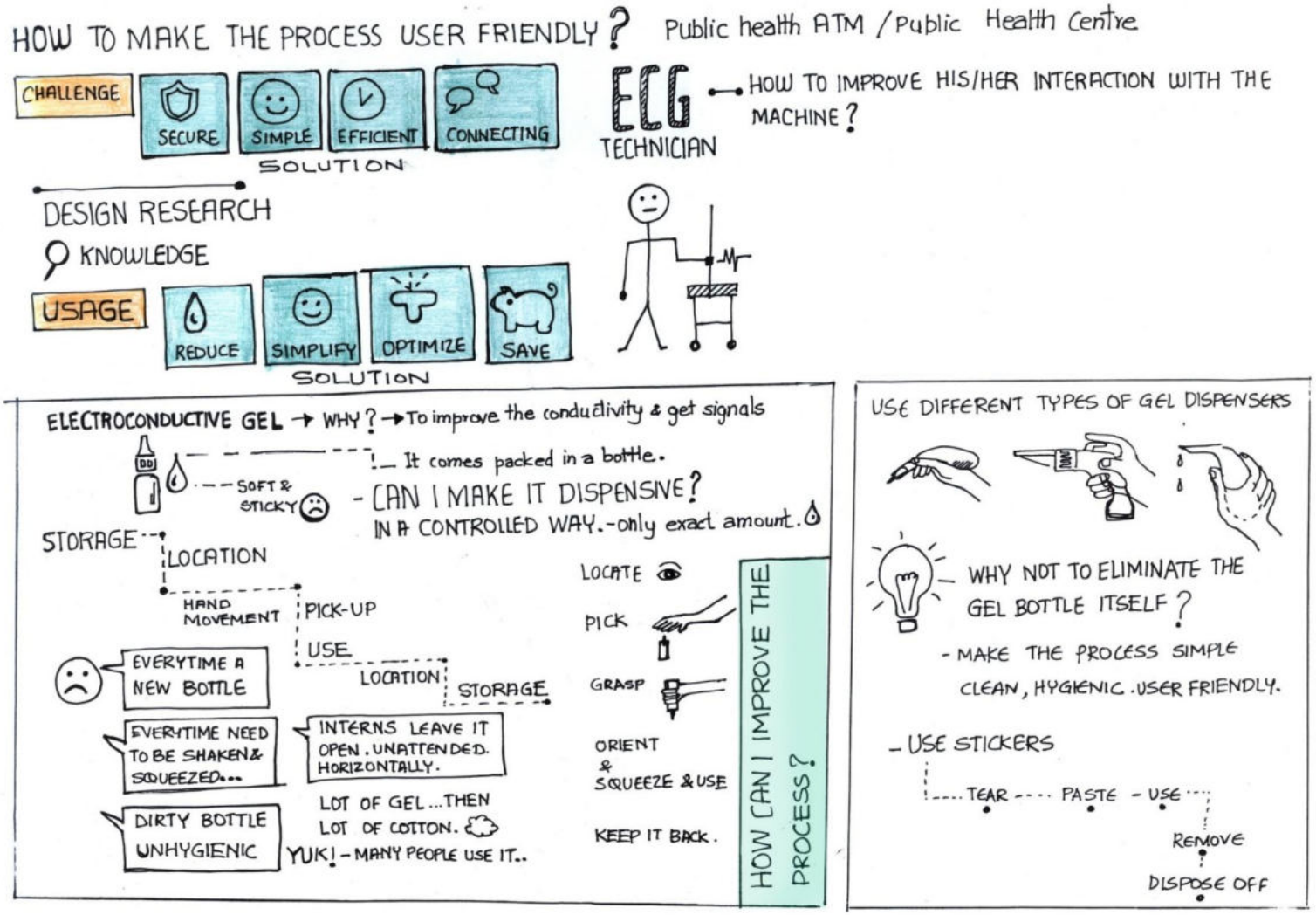


Fig. 7.1 Source: Author

7.1.2 Early Ideations

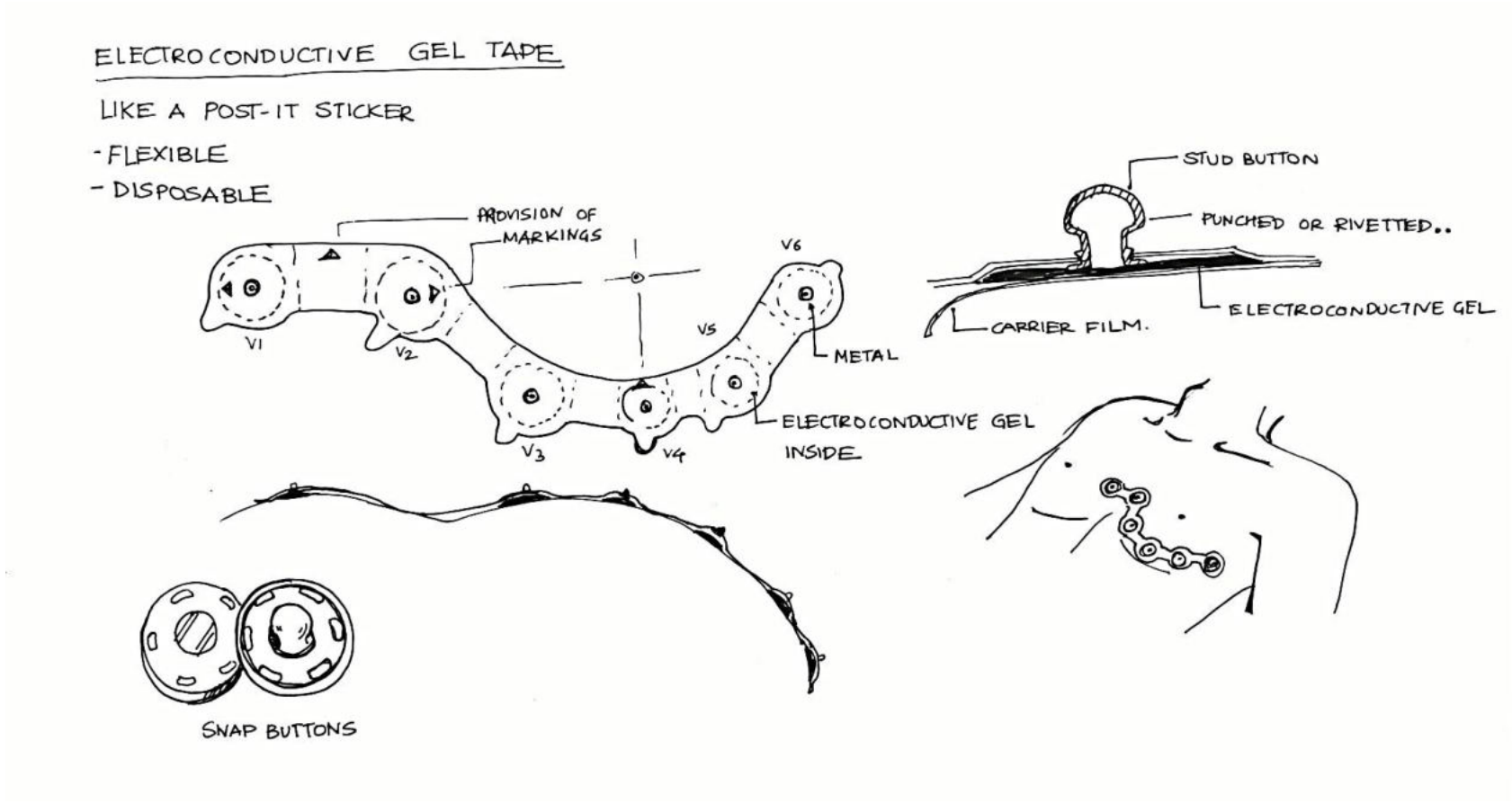


Fig. 7.2 Source: Author

7.1.3 Understanding the proposed process

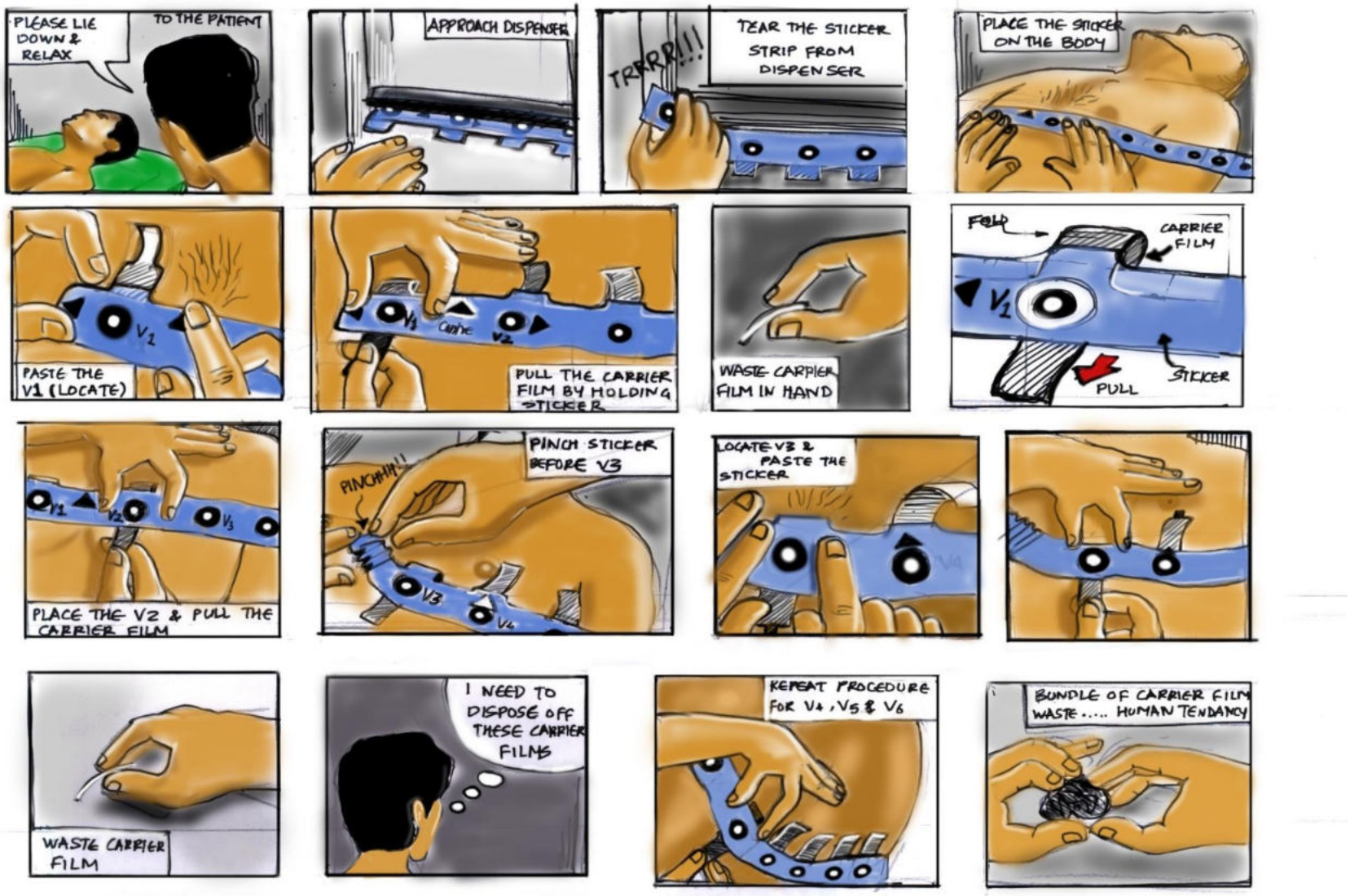


Fig. 7.3 Source: Author

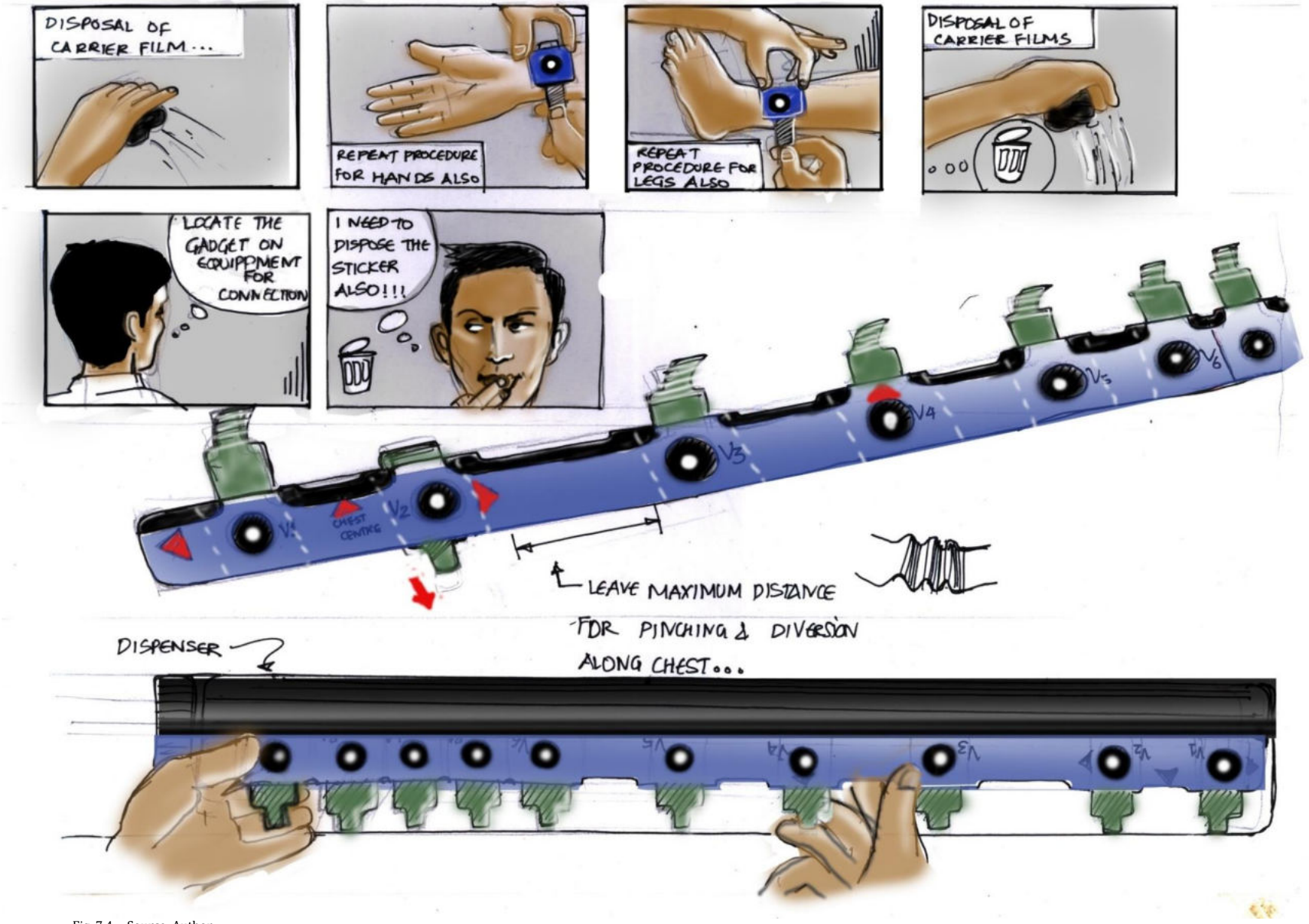
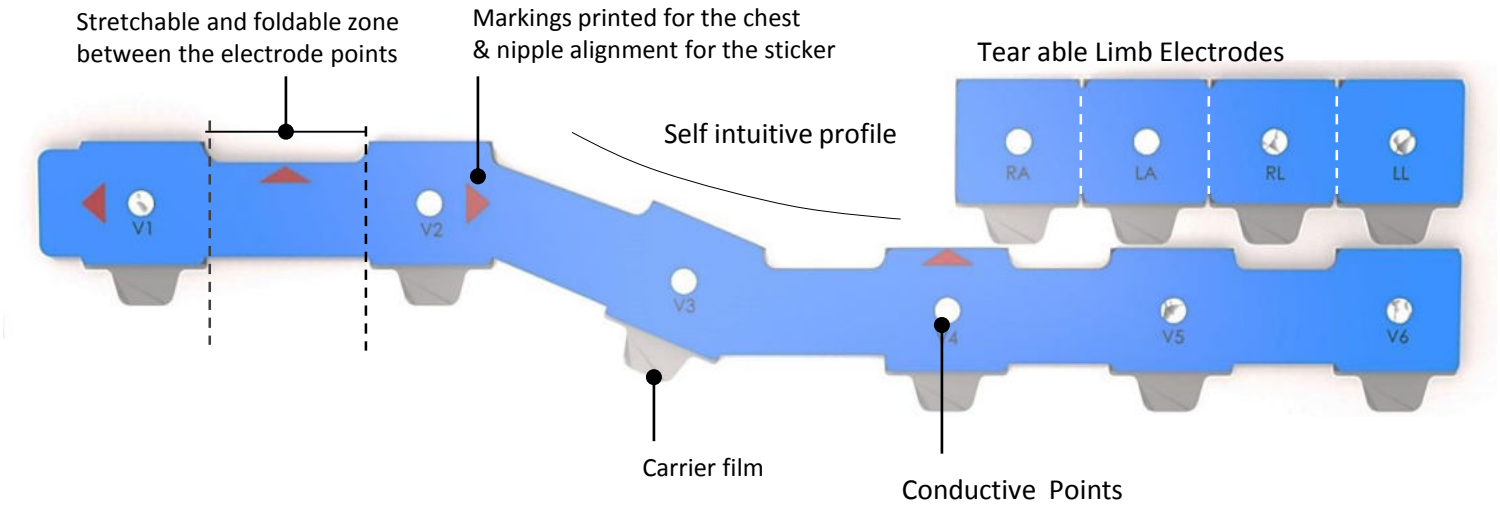


Fig. 7.4 Source: Author

7.1.4 The concept of pre- gelled electro conductive sticker

Stretchable pre gelled stickers with conductive points



Flexible printed circuit electrode

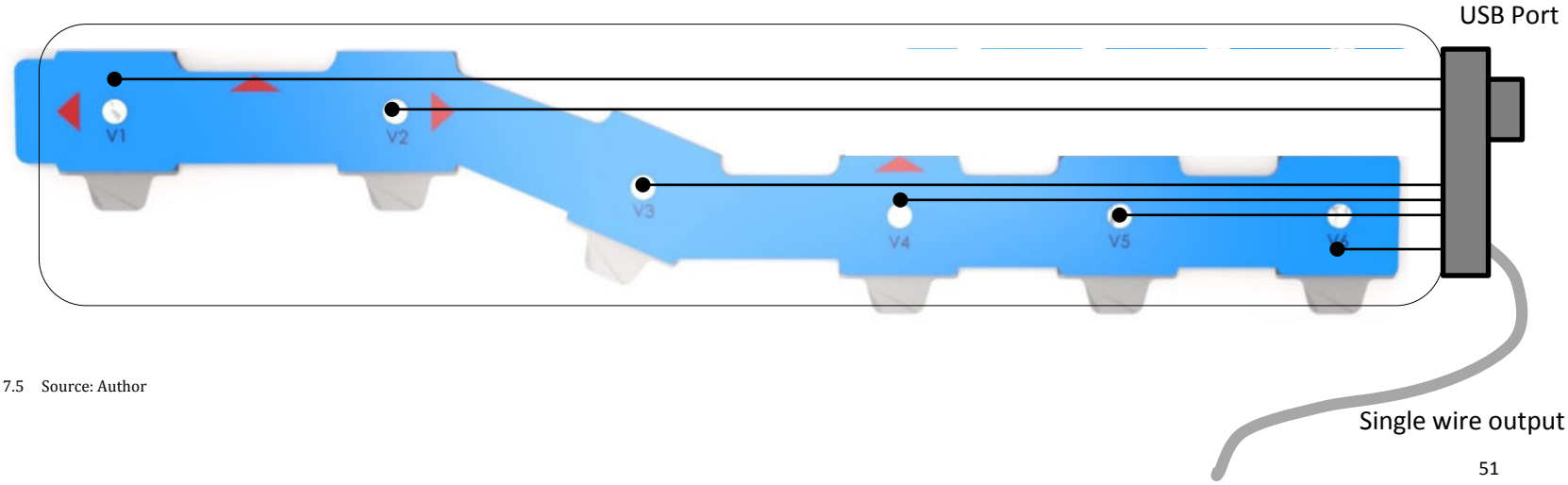


Fig. 7.5 Source: Author

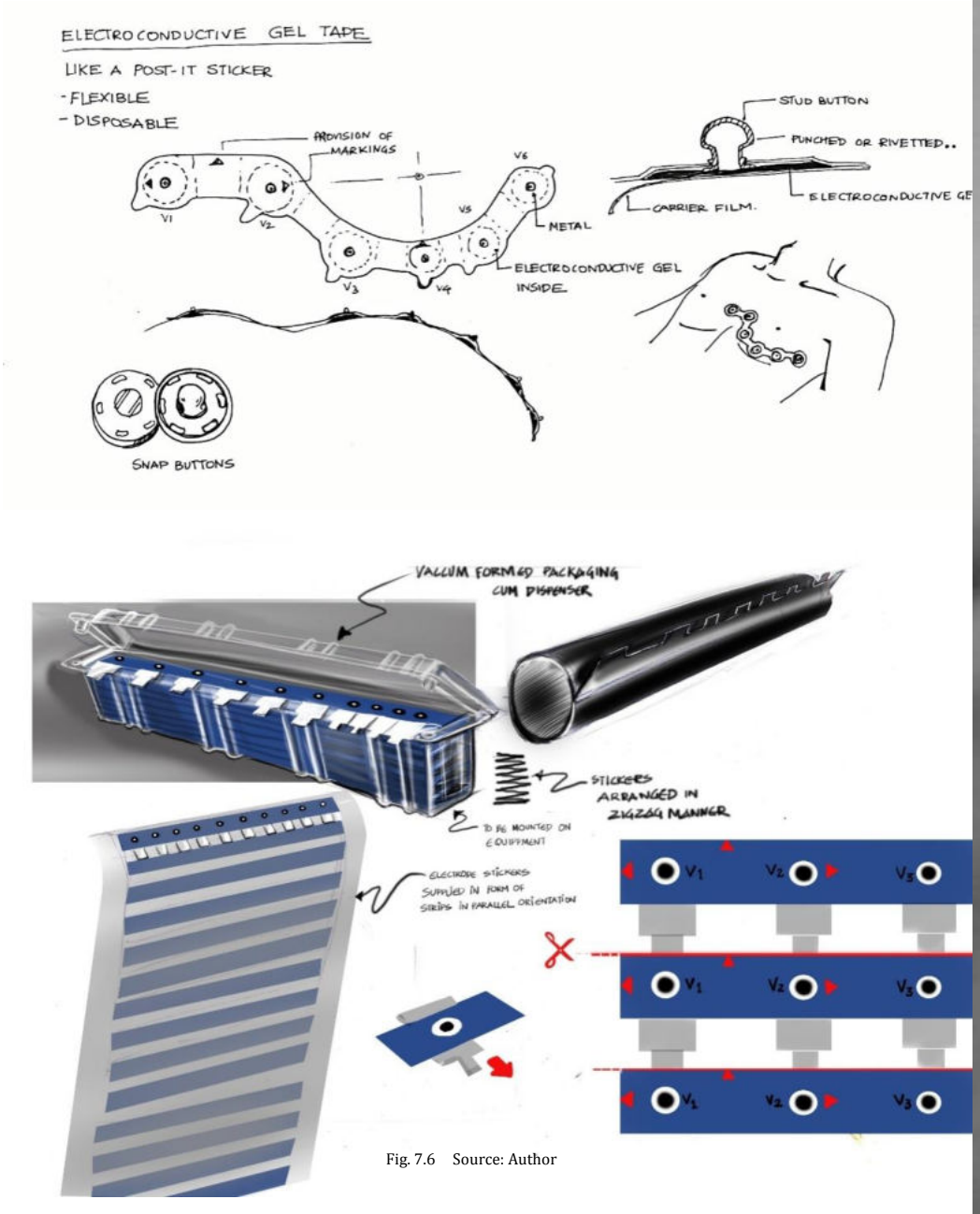
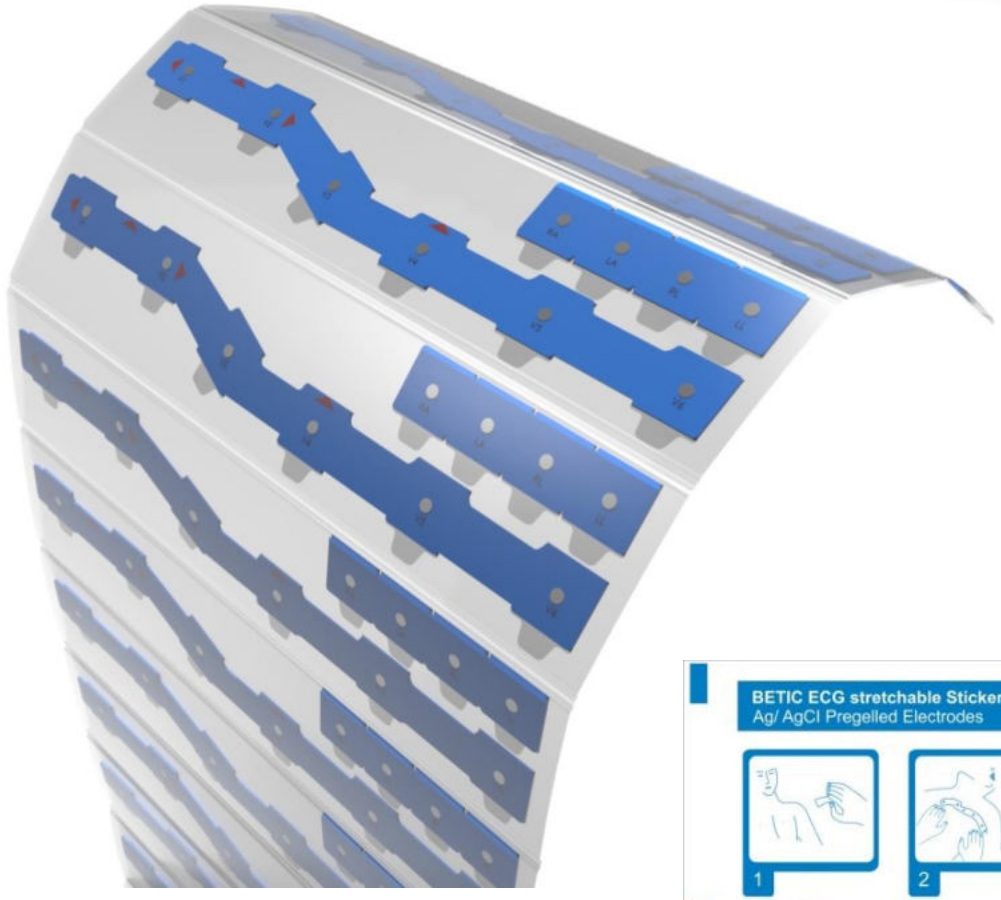
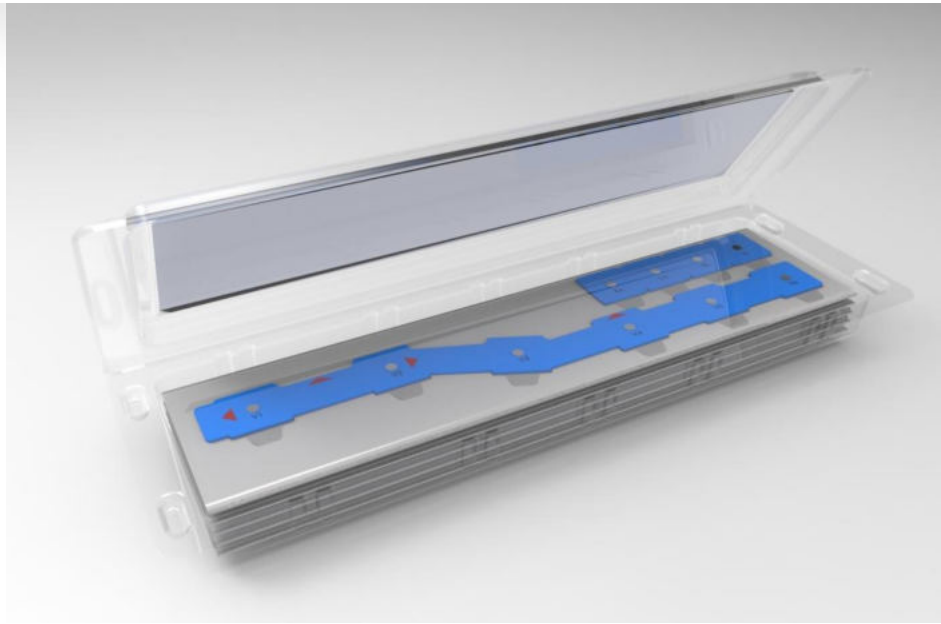


Fig. 7.6 Source: Author



Sticker electrodes provided in a pack of ten number

Fig. 7.7 Source: Author



Instructions provided on every sticker sachet

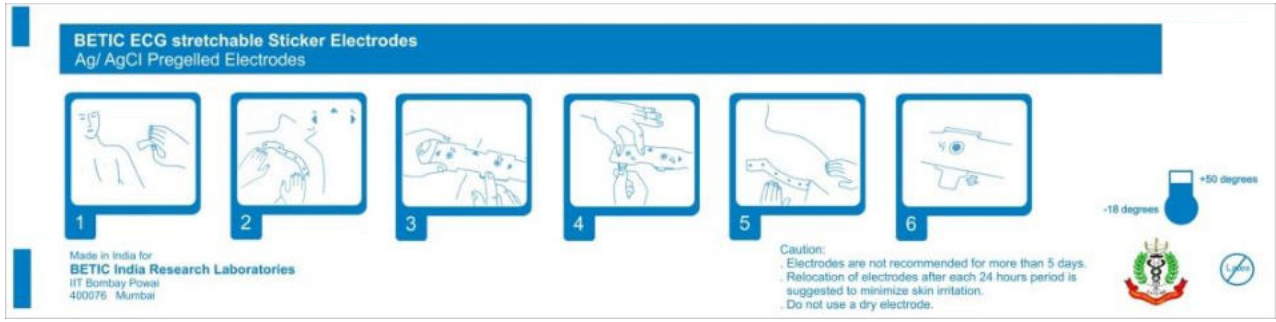


Fig. 7.8 Source: Author

7.2 Design Solution for Wire Entanglement

7.2.1 Brain storming

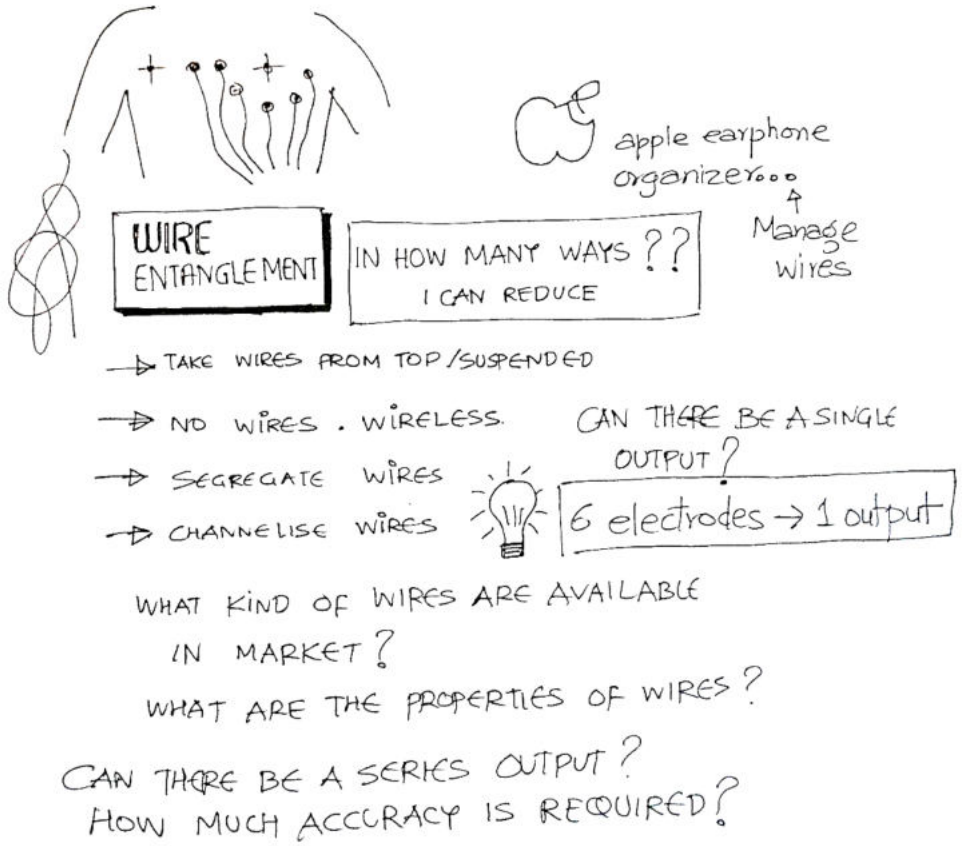


Fig. 7.9 Source: Author

7.2.2 Early Ideations

While surfing on the net, I came across flexible electronics with printed circuits. So, to avoid the six wires coming out from the chest, it was better to divert the wire signal traffic & channelize it to a single hub or unit from where the signal can be recorded. The advantage of this concept is that it will avoid un necessary entanglement of the wires coming out from the chest electrodes making the process simple,

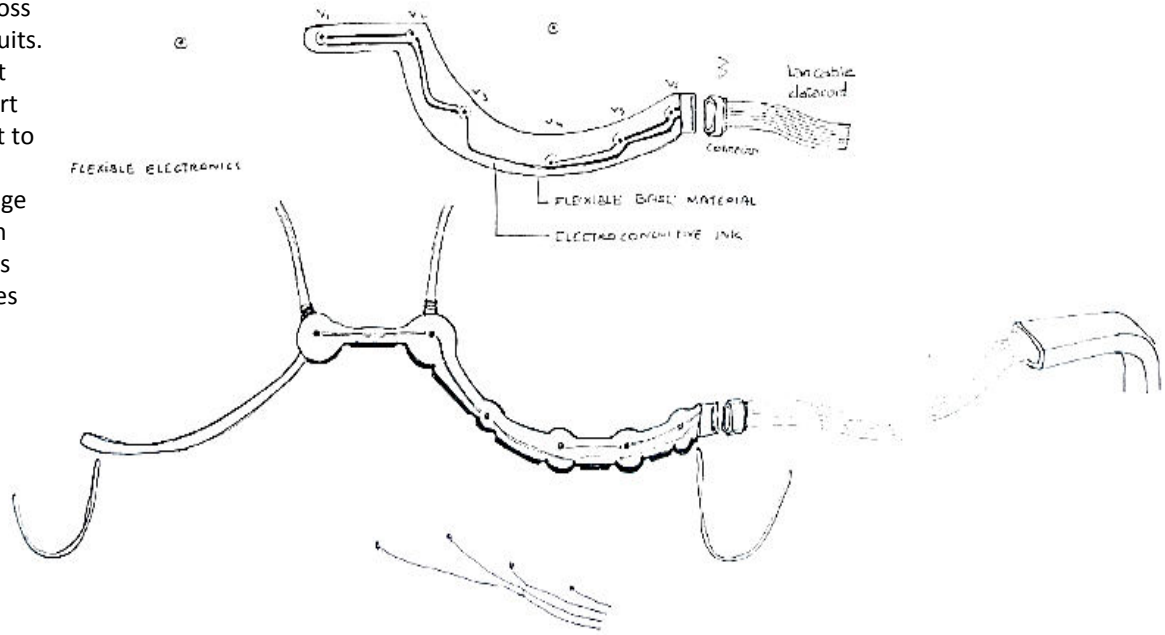
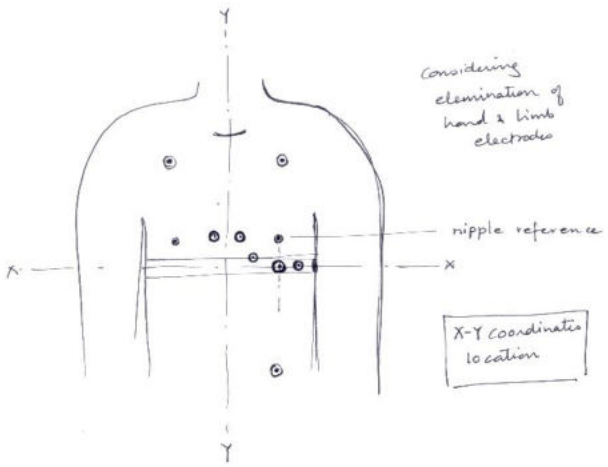
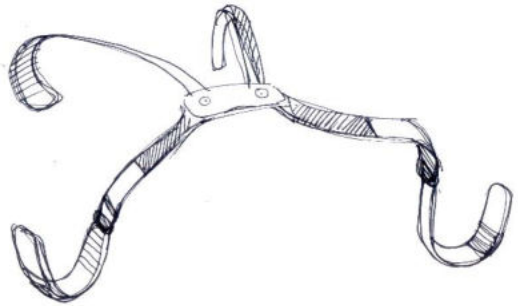
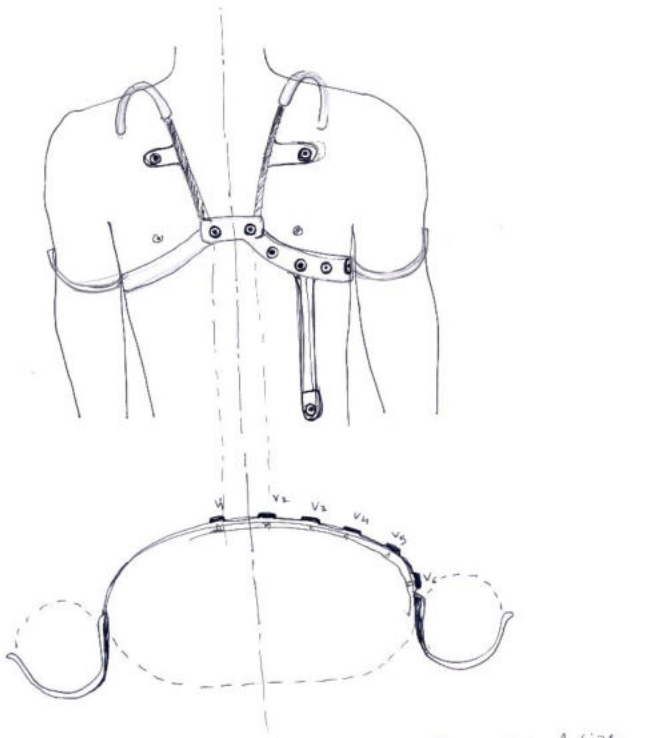


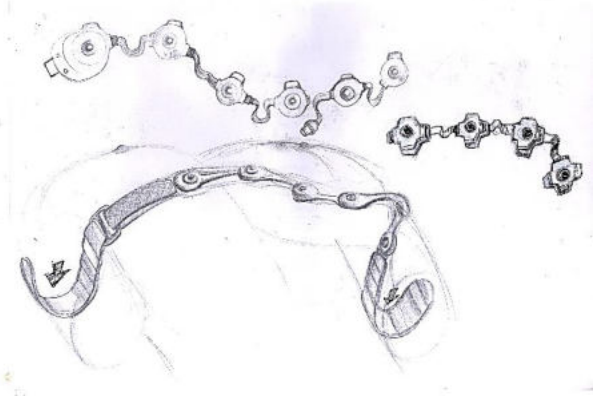
Fig. 7.10 Initial Ideations Source: Author

7.2.2 Early Ideations







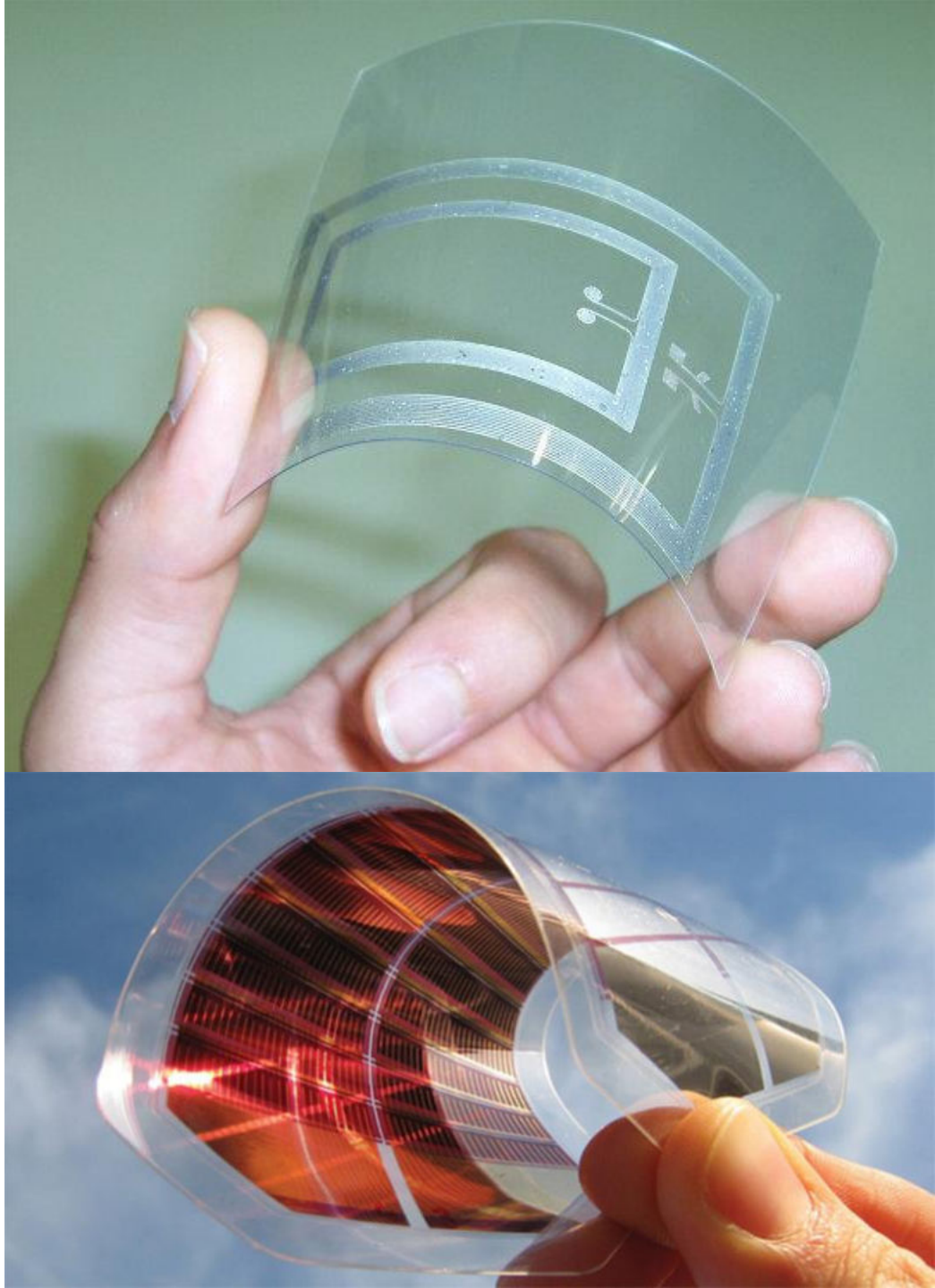


7.2.3 Understanding the flexible printed electronics

A visit to my friend Mr. Deepak Malani, from the Tree Lab department helped me to understand the working of flexible electronics. The material (PET) is flexible enough to hold the electro conductive ink on it.

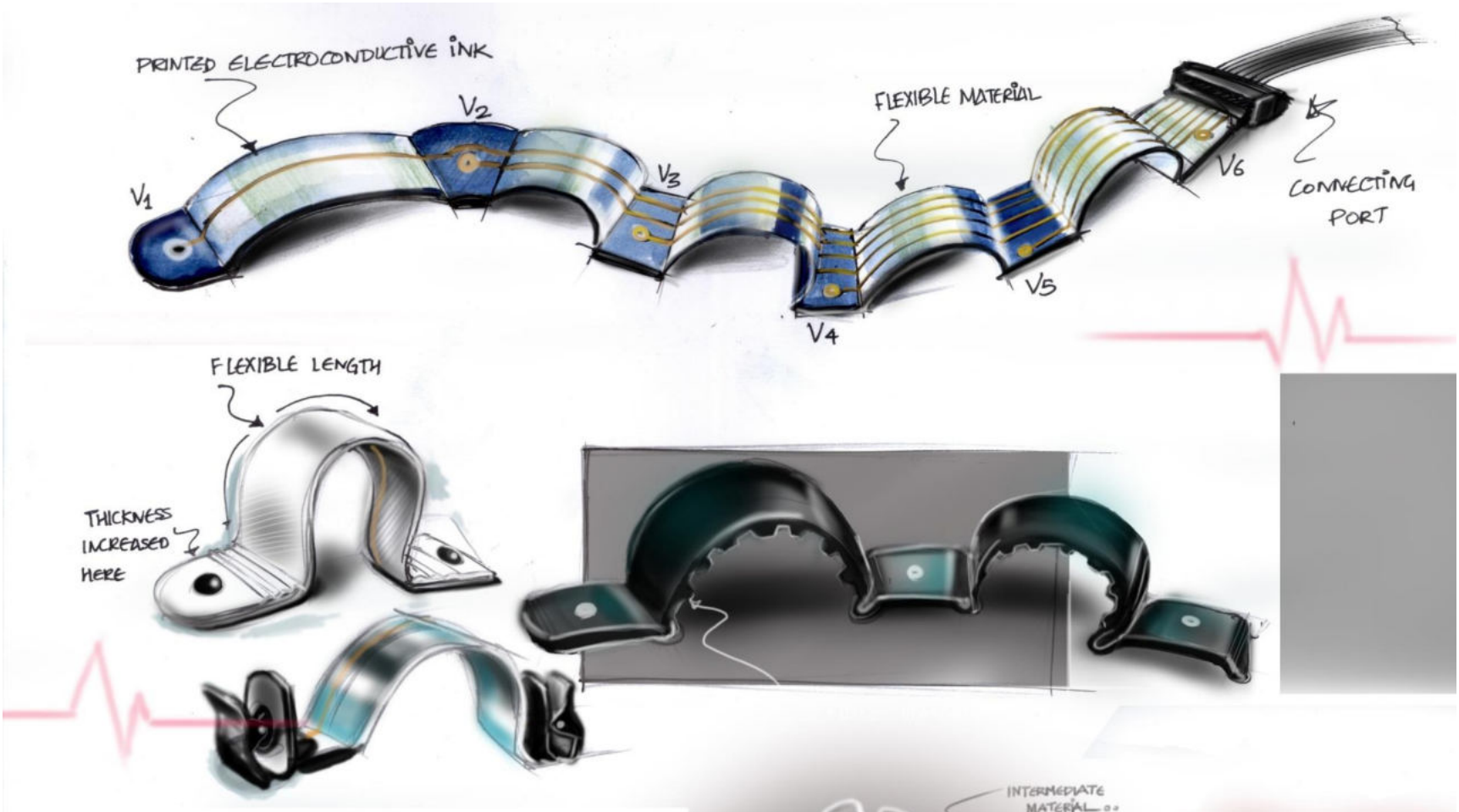
The other option is using electro conductive thread , wherein one can use fabric as a base material for holding the conductive thread. Considerably, electro conductive threads are cheaper than the electro conductive ink.

Even, the ink can be screen printed which is an added advantage for mass manufacture of the gadget.



Pic. 7.12 Source: https://electrosome.com/silver-ink-electronic-circuit/
http://eandt.theiet.org/news/2012/sep/flexible-electronics.cfm

7.2.4 The concept – Chest Electrode gadget



The concept uses PET as a substrate material for holding the screen printed electro Conductive ink for transmission of the electrical signals from the source point. The flexibility of the material can accommodate any varying body sizes.

Fig. 7.13 Source: Author

As per the proposed concept, the Chest electrode gadget consists of 3 layers. A base layer with adhesive on it at a required defined location at all the six points. The middle layer above it will be the flexible printed circuit film (PET) Which is flexible enough to hold the deformations.Ref fig. (7.14)
The topmost layer is made up of flexible material (silicon mold)substrate with markings at every 6 points.

There will be a common output in the form of a hub which will give out a port which can be either an USB based port or it can be a wireless gadget with Bluetooth connection.

The gadget can hold a battery of 9 volts to complete its basic function of recording the signals.

Once, the sticker is aligned on the chest, the gadget can be placed over the required points & the readings can be obtained.

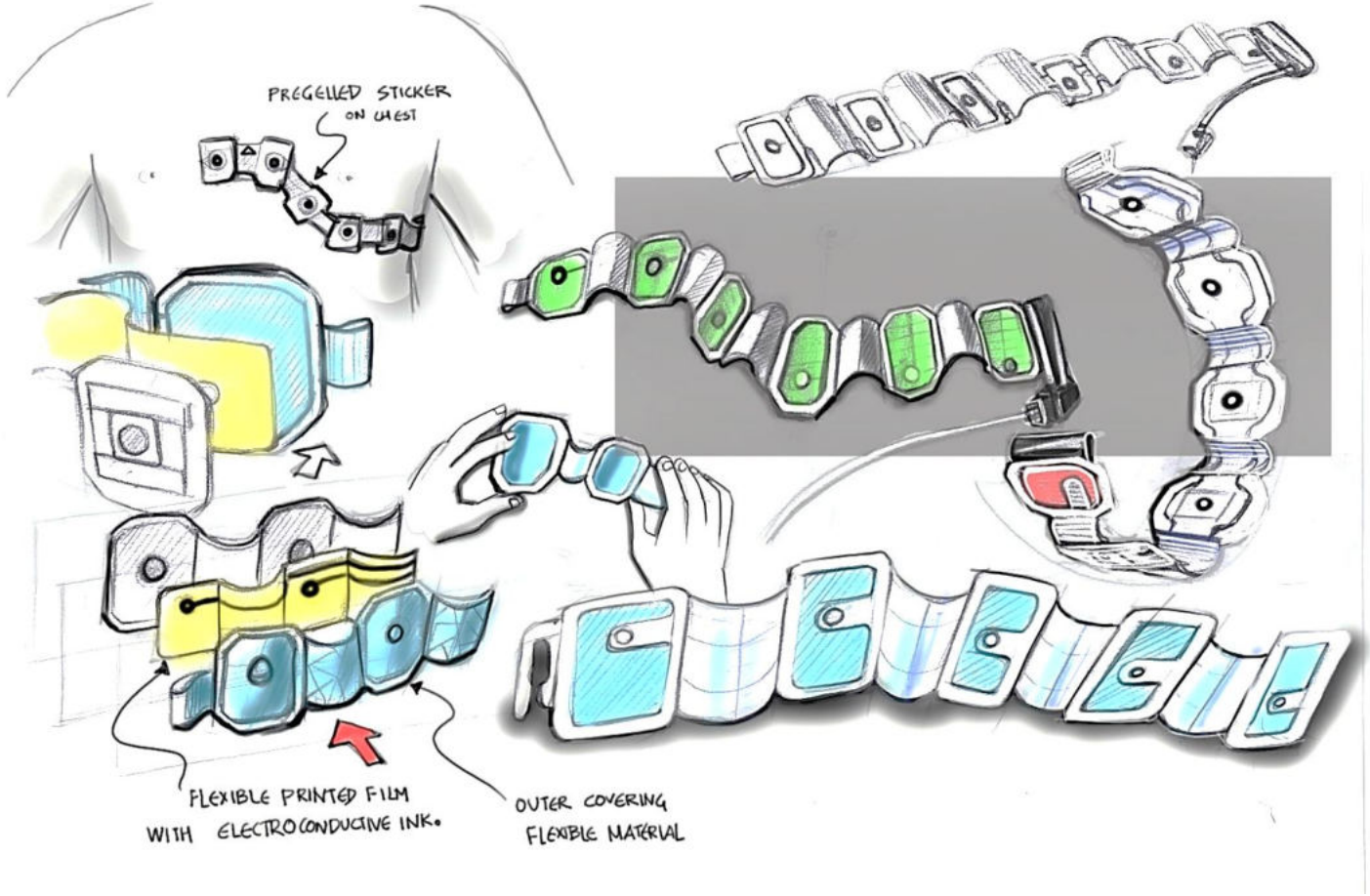


Fig. 7.14 Source: Author

7.3 Redesign of Hand & Limb electrodes

7.3.1 Brain storming

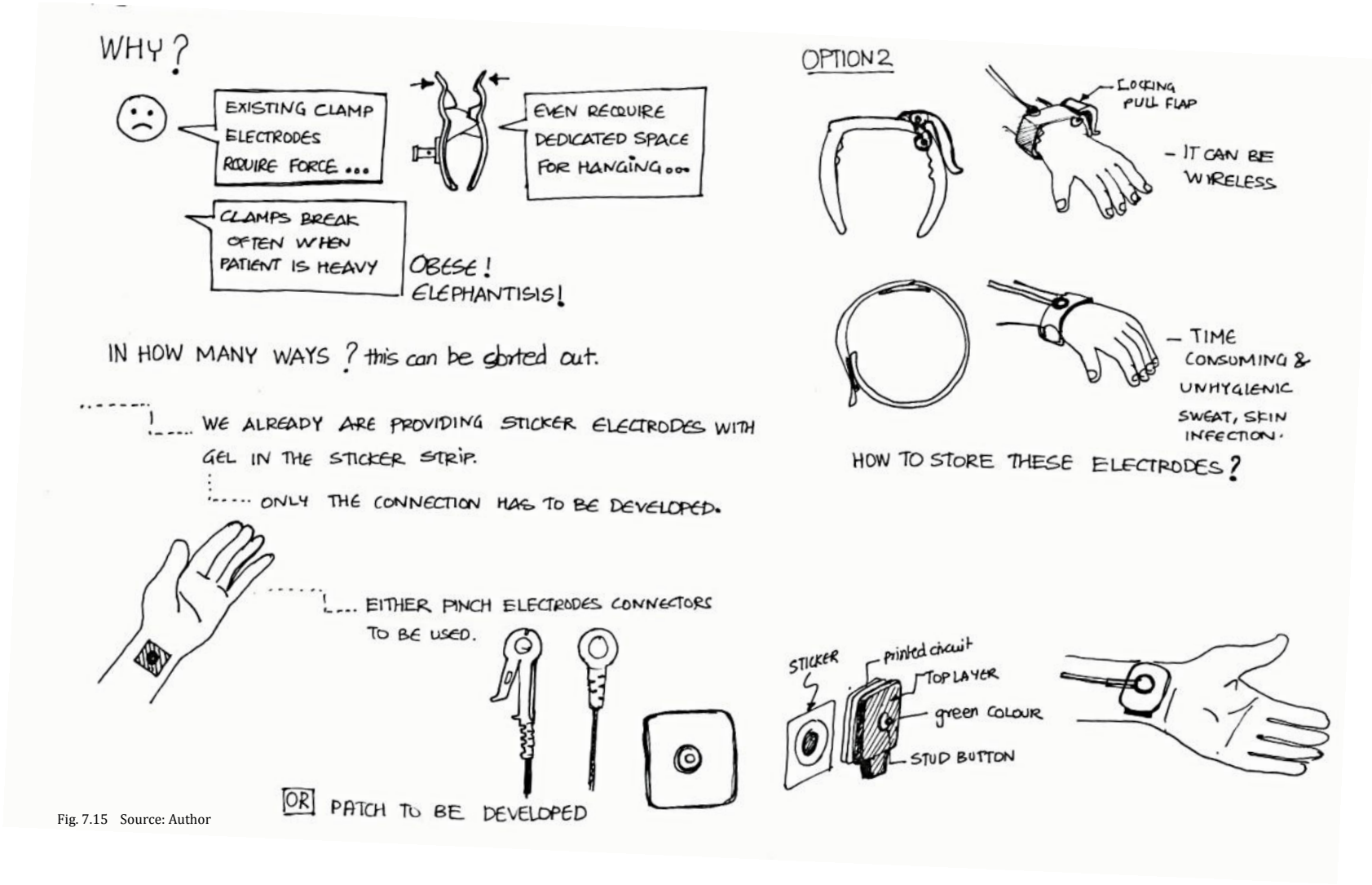


Fig. 7.15 Source: Author

7.3.2 Ideations

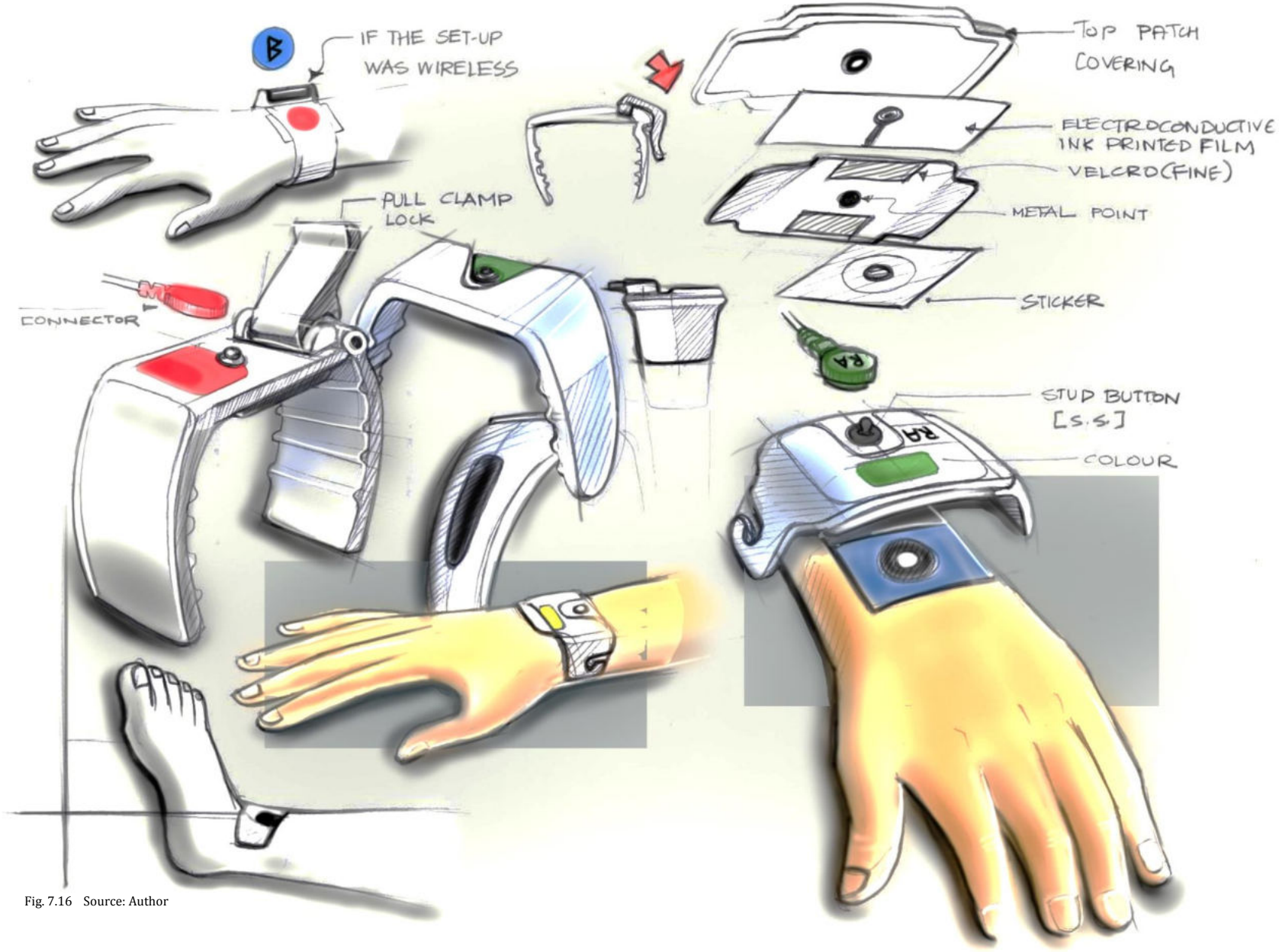


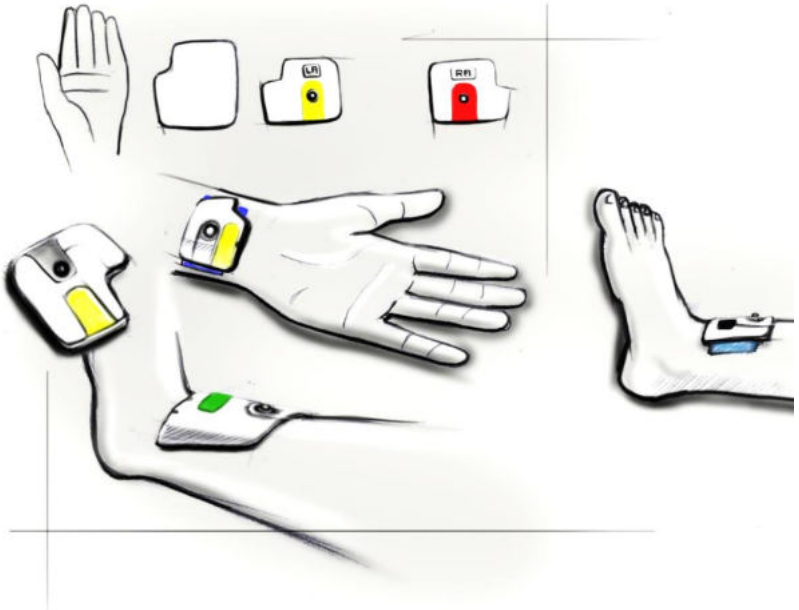
Fig. 7.16 Source: Author

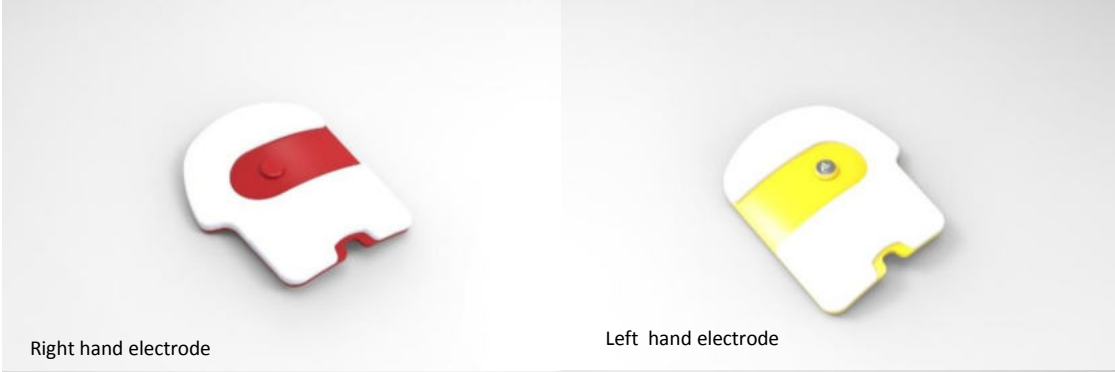
7.3.3 Concept

Here the main intention was to make the limb electrode as compact as possible. First, the sticker pre gelled electrode will be pasted on the limbs. Then the electrodes will be adhered on the sticker surface. There will be a detail on the sticker material & the limb electrode such that they get stuck together. Ref fig. 7.17 Inspired from the adhesive Velcro in baby pampers.

Even visually it has been tried to give the hand & leg electrodes a different treatment in terms of shape & color.

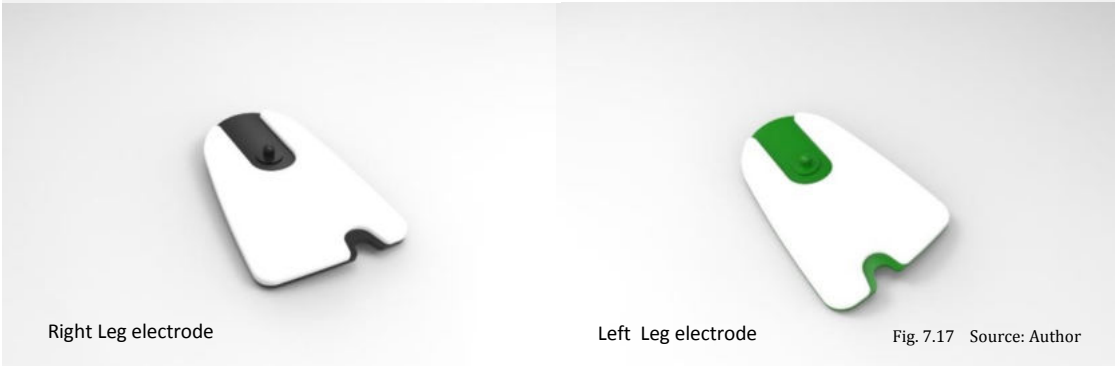
The hand electrodes have been provided with Hand profile while the leg electrode symbolizes the leg profile which can help the user to visually differentiate & identify the electrodes & help in easing the process.





Right hand electrode

Left hand electrode



Right Leg electrode

Left Leg electrode

Fig. 7.17 Source: Author

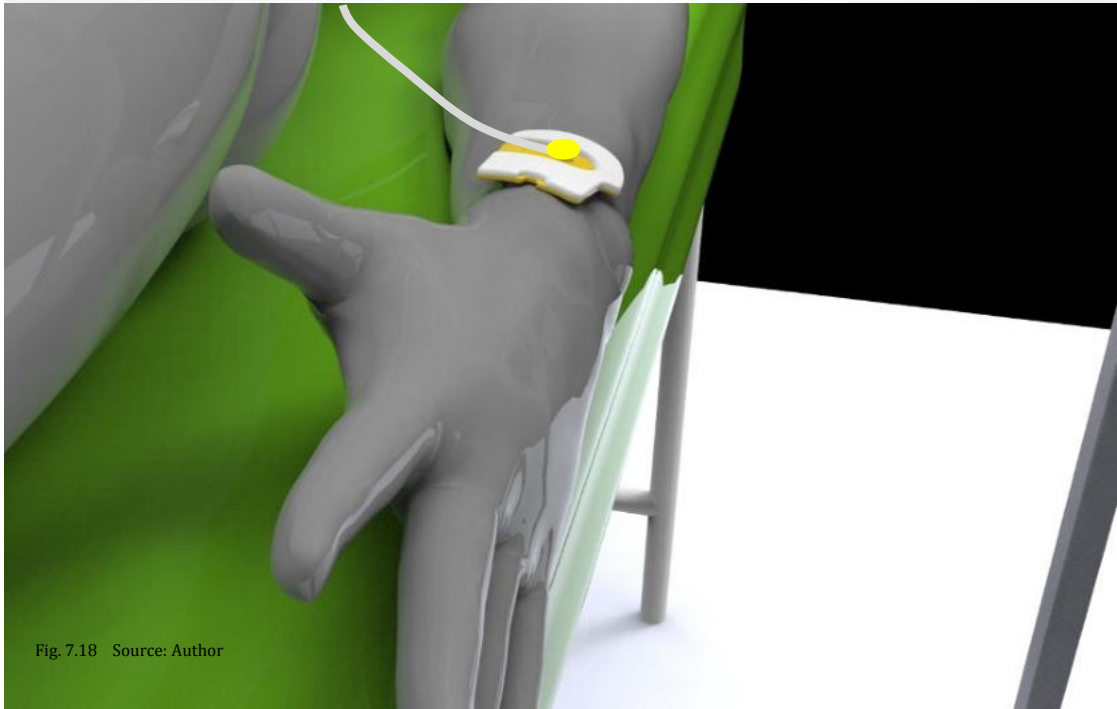


Fig. 7.18 Source: Author

7.3 Design of overhead boom

7.4.1 Brain storming

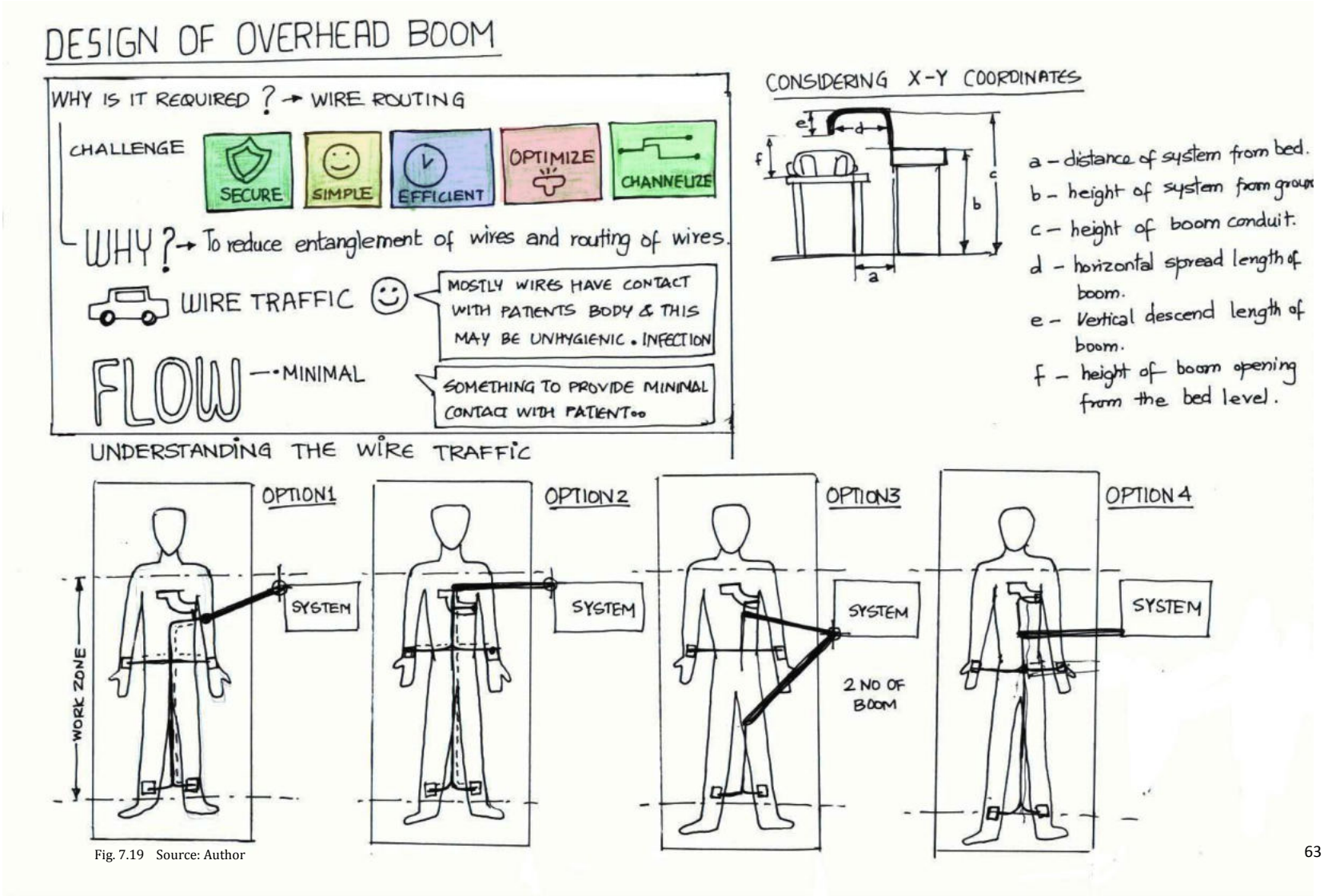


Fig. 7.19 Source: Author

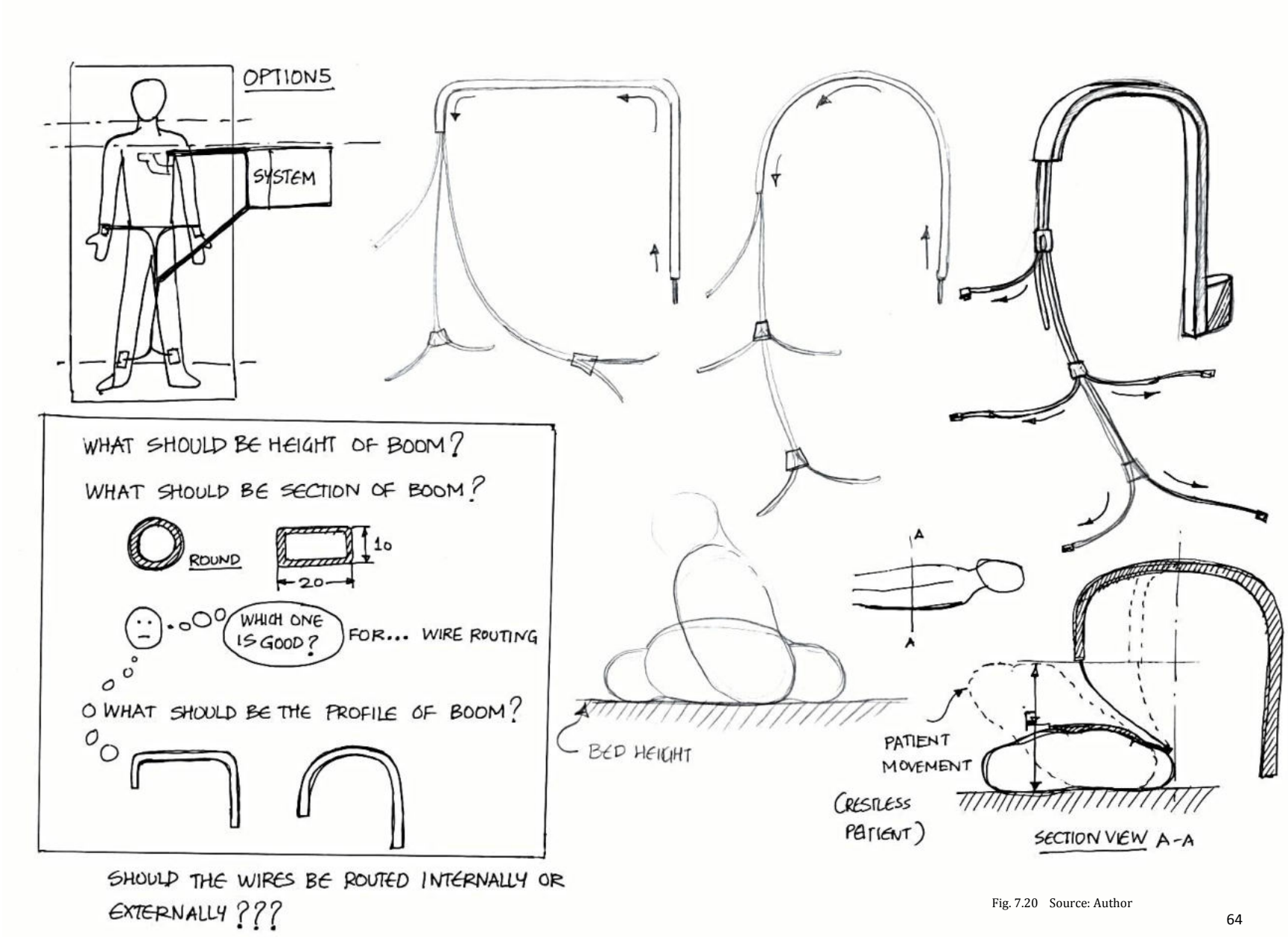


Fig. 7.20 Source: Author

7.4.2 Early Ideations

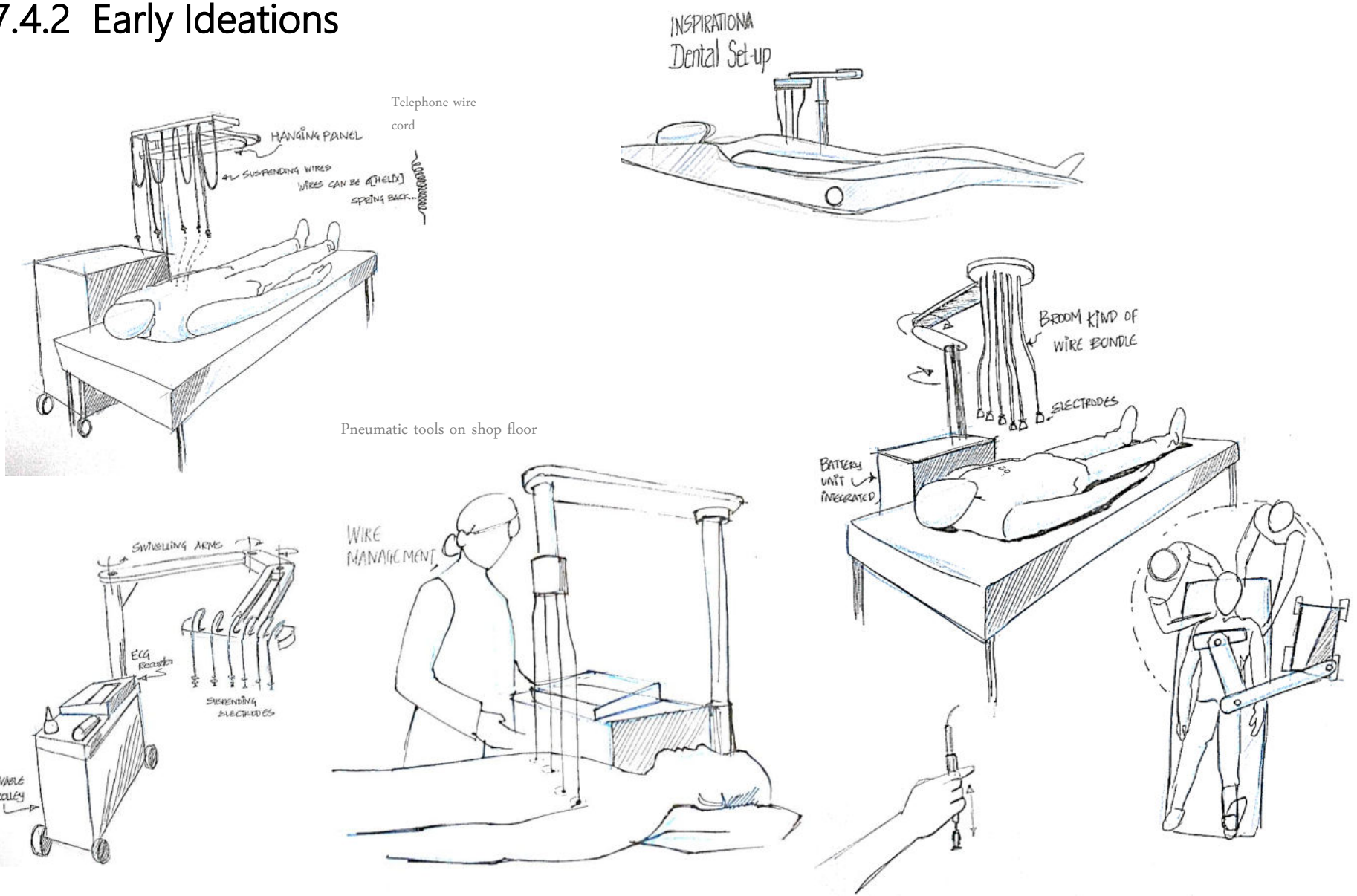


Fig. 7.21 Source: Author

7.4.2 Early Ideations

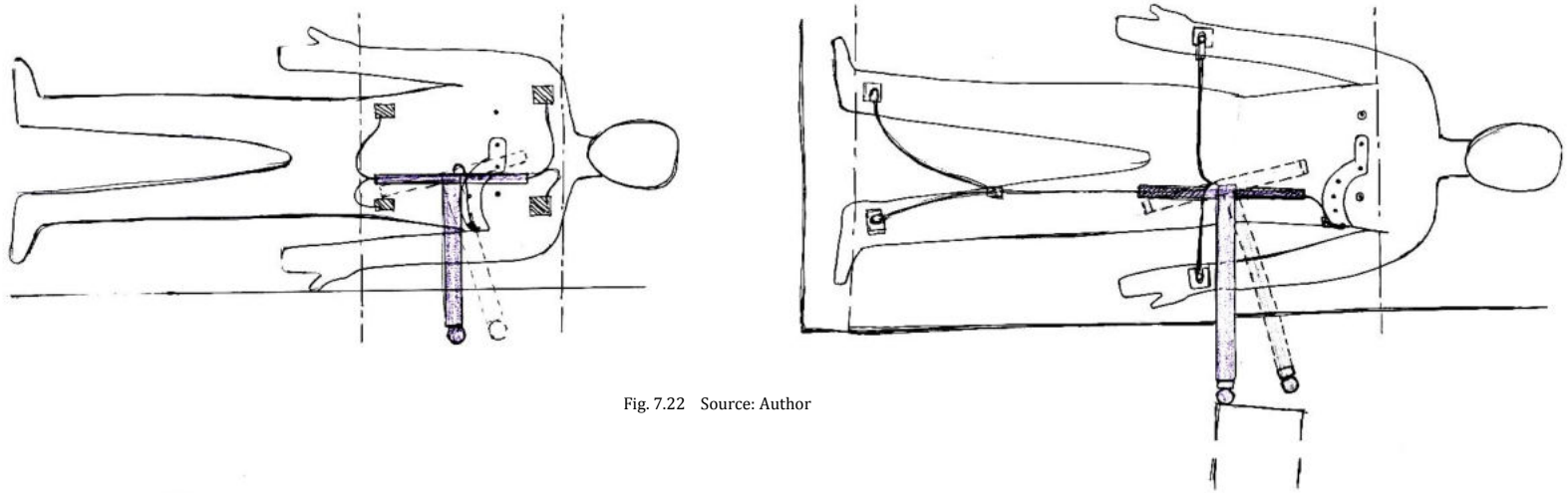


Fig. 7.22 Source: Author

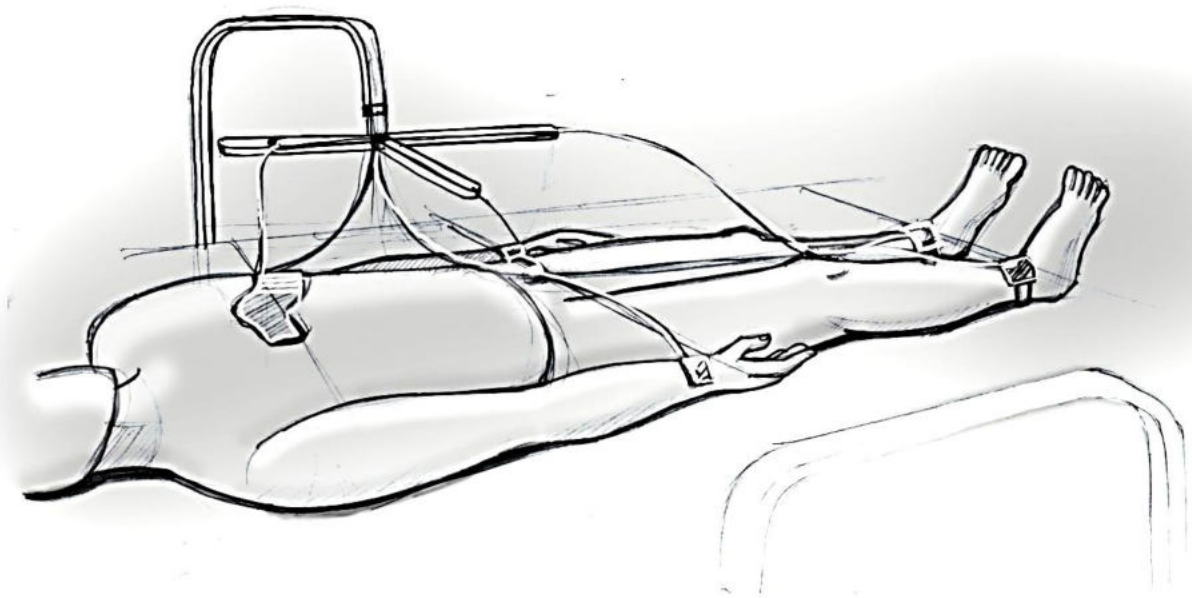
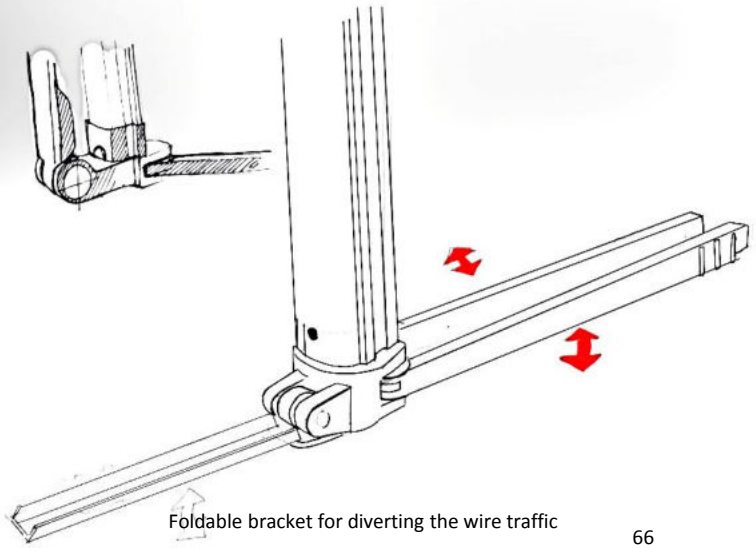


Fig. 7.23 Source: Author



Foldable bracket for diverting the wire traffic

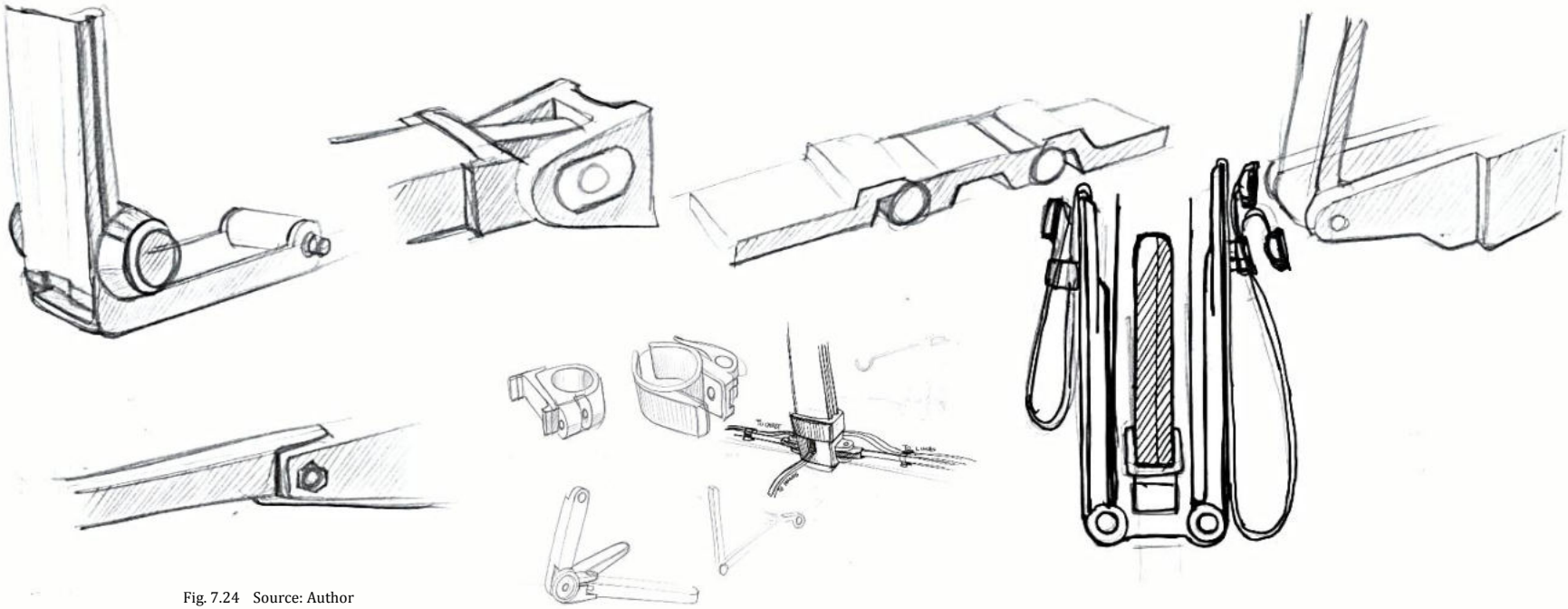
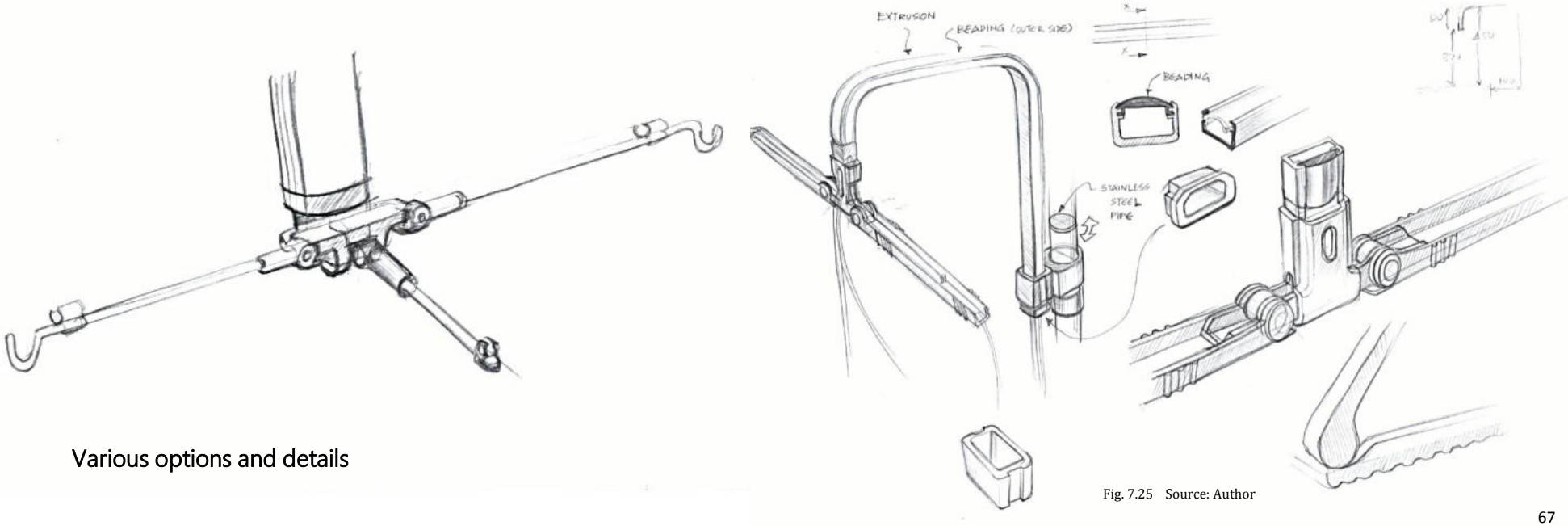


Fig. 7.24 Source: Author



Various options and details

Fig. 7.25 Source: Author

7.4.3 Concept

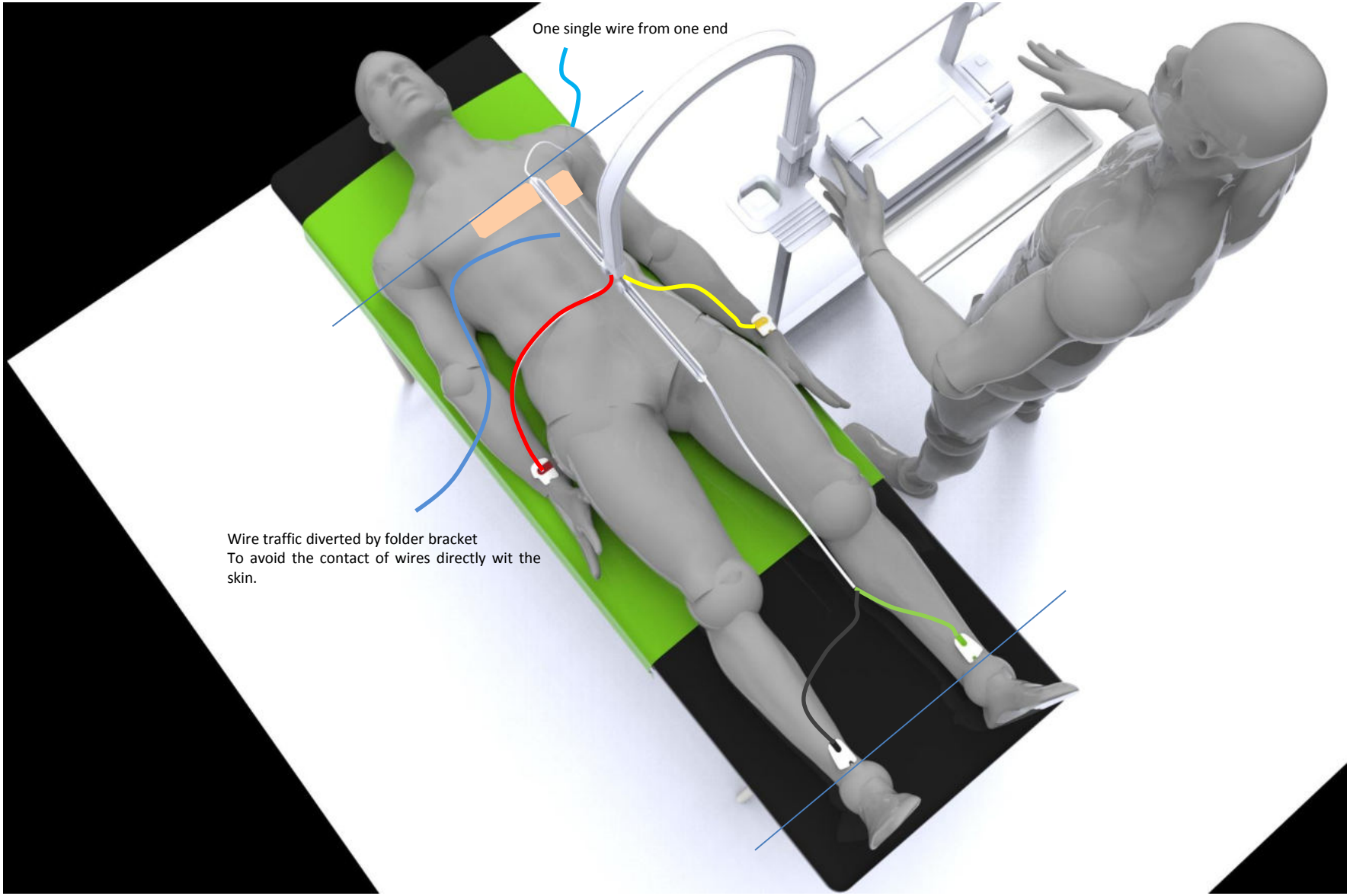


Fig. 7.26 Source: Author

08

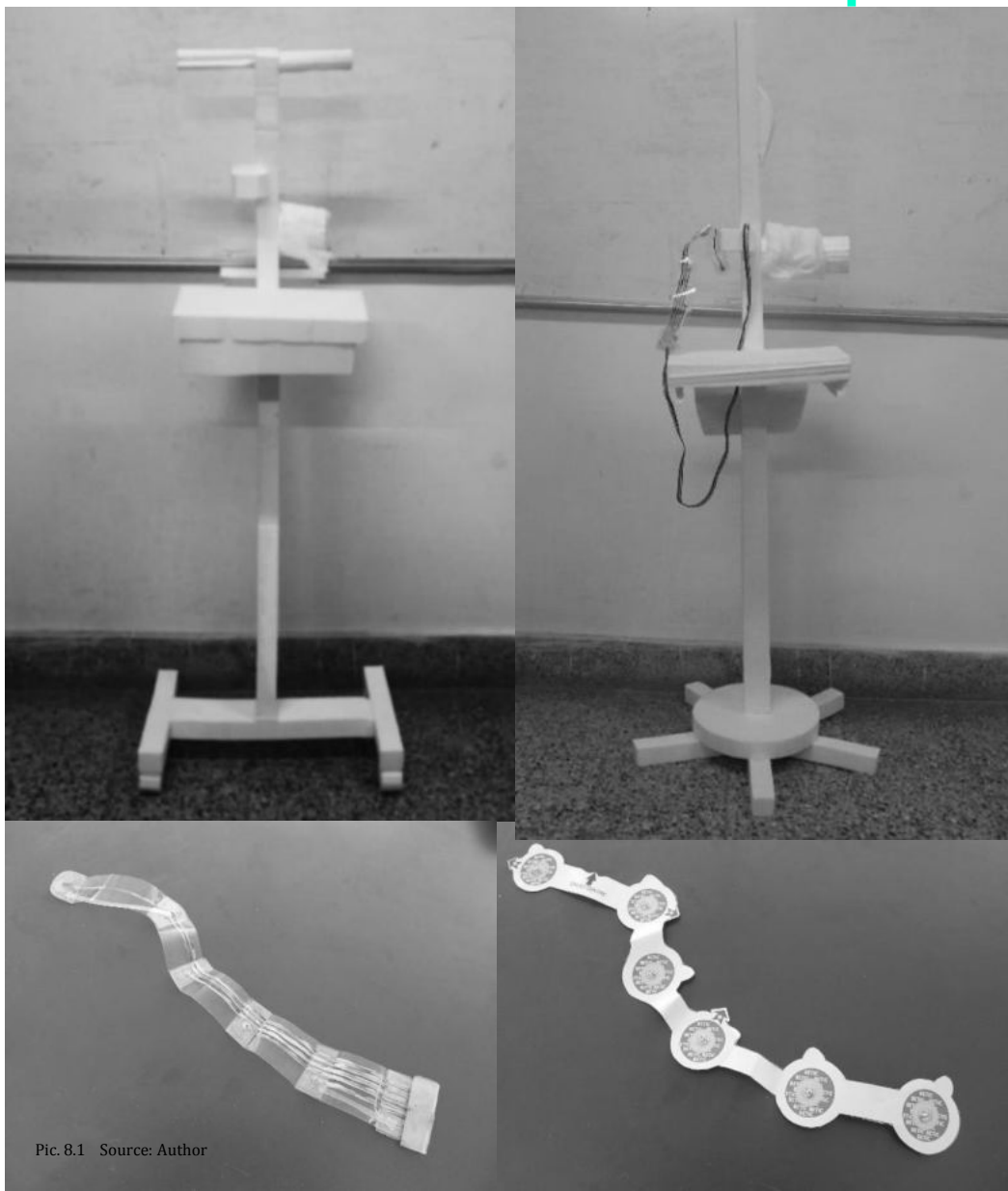
QUICK MOCK UP & ROLE PLAY

8.1 Proportion study & verification of concept

Quick mock ups were done to actually understand the proportions of the trolley for ECG initial ideations.
The role play was conducted by enacting the process with dummy mock up and proposed concepts.

The idea of adhesive sticker , its orientation with respect to the chest .The activity of the chest gadget to be placed after on the electrode sticker was also verified.

The micro level activities were noted down right from the start of the process till the disposal of the electrode gelled stickers.

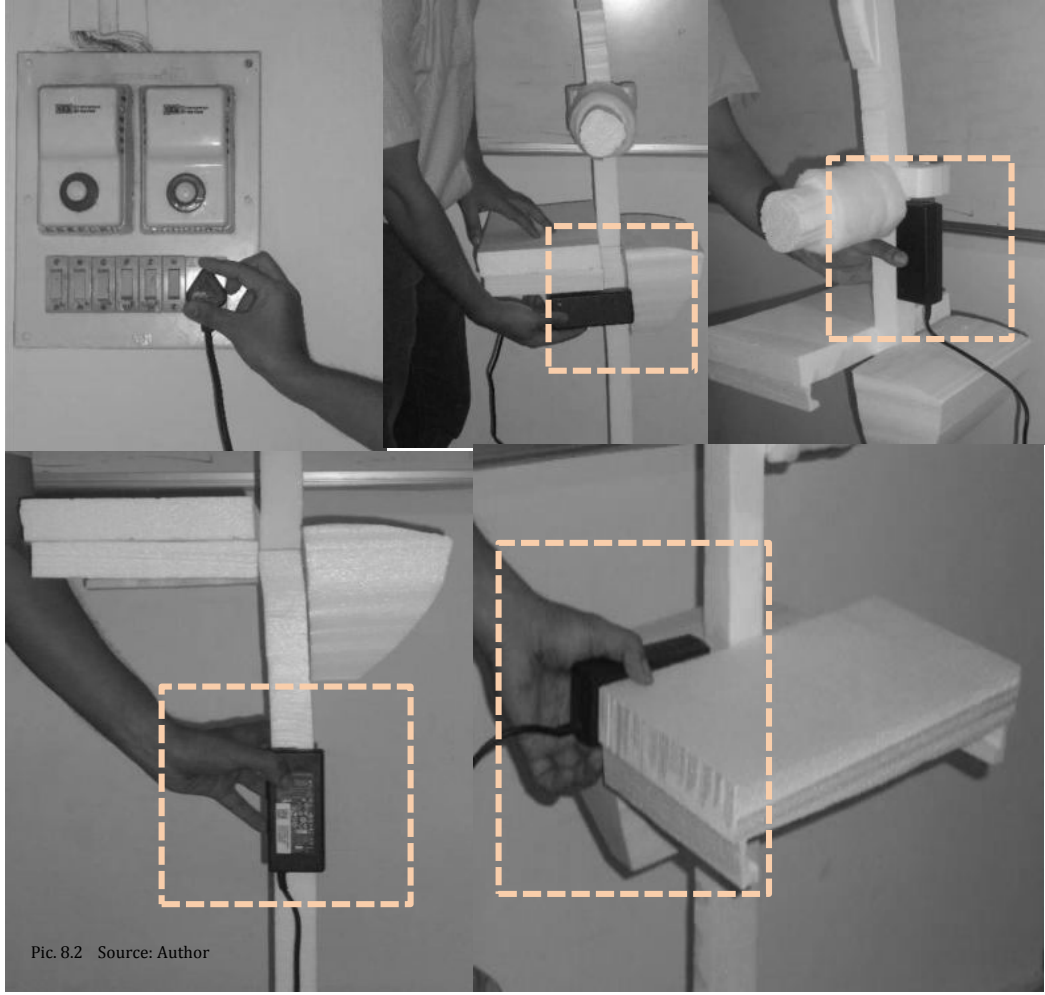


Pic. 8.1 Source: Author

Quick mock ups were done to actually understand & validate the initially ideated concepts.

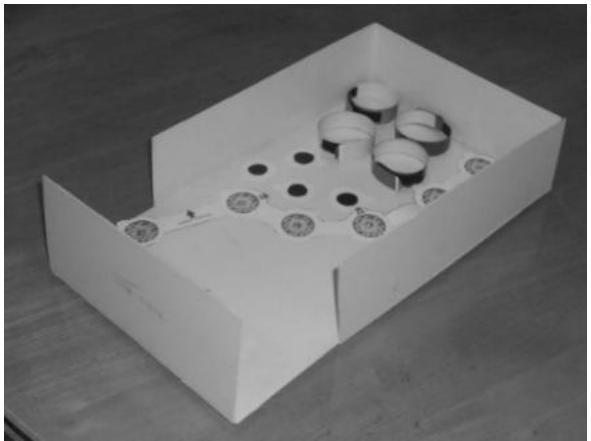
Activity 1 : The ECG technicians will locate the adapter & would possibly would like to charge the machine in the start.

Possible location of Adapter on the Cart structure



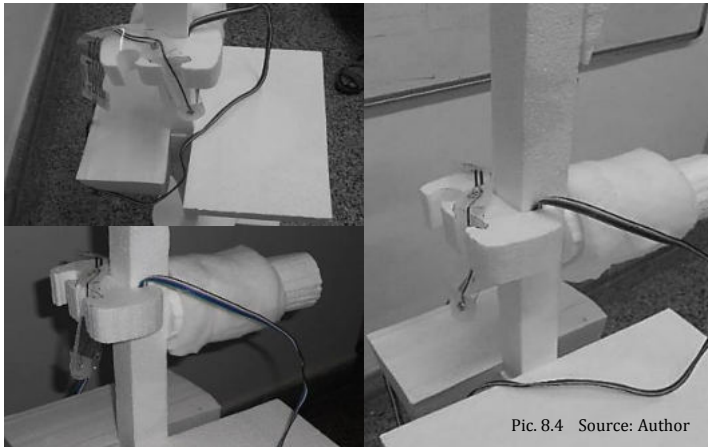
Pic. 8.2 Source: Author

Exploration required for storage location of the electrodes & accessories



Pic. 8.3 Source: Author

Exploration for storage of the gadget for chest lead electrodes



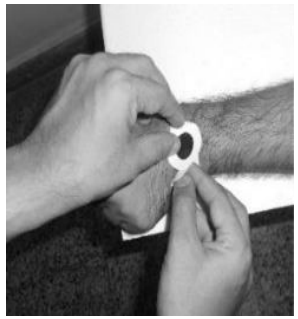
Pic. 8.4 Source: Author

Placement of Chest lead
Stickers on the chest.

Pic. 8.6 Source: Author

Pic. 8.5 Source: Author

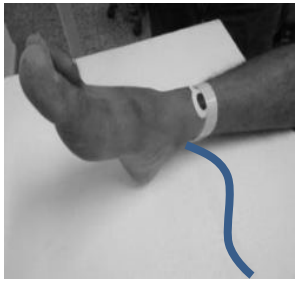
Placement of Sticker electrode for accurate
positioning and electrode placement.



The process of sticking the sticker electrode & then the belt clamp Hand electrodes

Approach towards picking chest lead gadget &
placing it to align on the sticker electrodes.

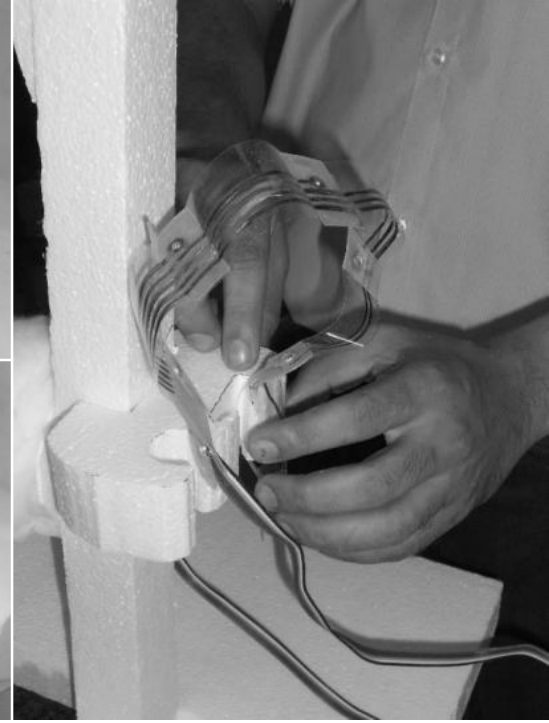
Pic. 8.7 Source: Author



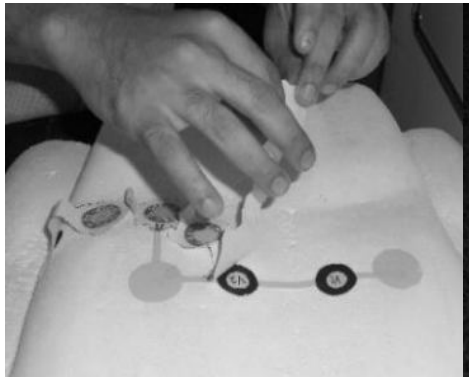
The process of sticking the sticker electrode & then the belt clamp Limb electrodes

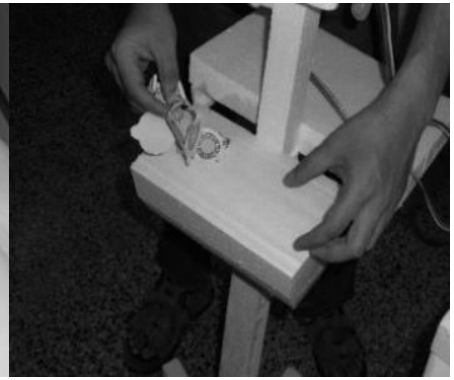
Pic. 8.8 Source: Author

Pic. 8.9 Source: Author Recording of the ECG Signal



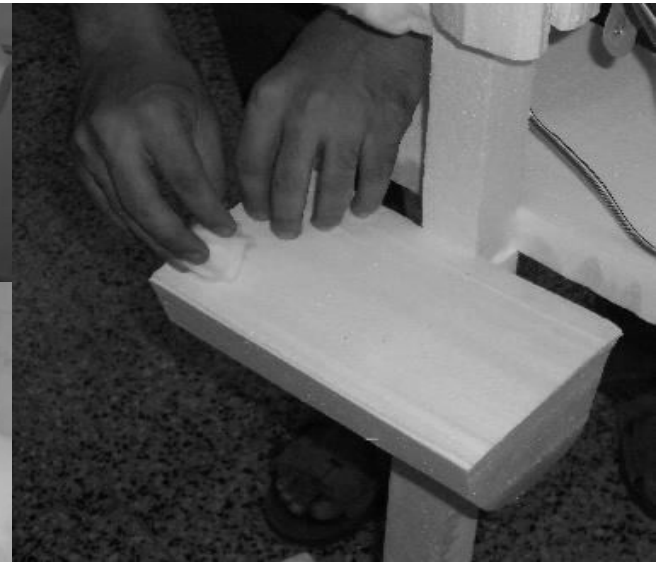
Pic. 8.10 Source: Author Once the recording is done, remove the Chest lead gadget & place it back on the system





Removal of the chest sticker & disposing in the utility box.

Pic. 8.11 Source: Author



Use of cotton speb to clean the jelly from the chest & limb electrodes & Disposal in the utility box.

Pic. 8.12 Source: Author

8.2 Feasibility & Ergonomic study

Quick trial was done for Body Analysis for activities, hand to eye coordination and users difficulties.

Quick trial was done for Body Analysis for activities, hand to eye coordination proportions and system handling.

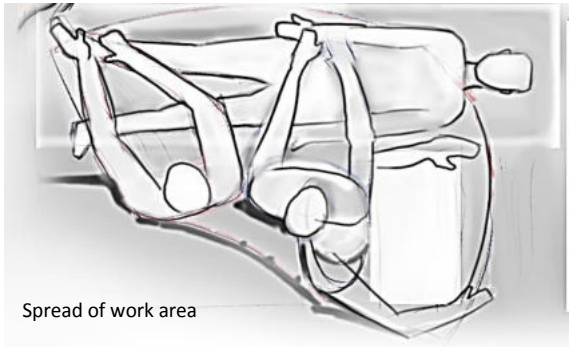
Pic. 8.13 Source: Author

Considering the environment in an OPD room wherein 100 to 150 patients come for check up, the ECG technician has to stand for quite considerable amount of time. All the peripheral set up & activities also required to be done in standing position.

Considering this, there are chances of Strain in the lumbar area and cervical.

To eliminate this, the work zone needs to be defined & the height of the work should be adjusted to relive the pain.

For this the proper ergonomic data for ECG machine to user height must be considered.



Different types of activities Fig. 8.14 Source: Author

Considering the important strain points in the body.

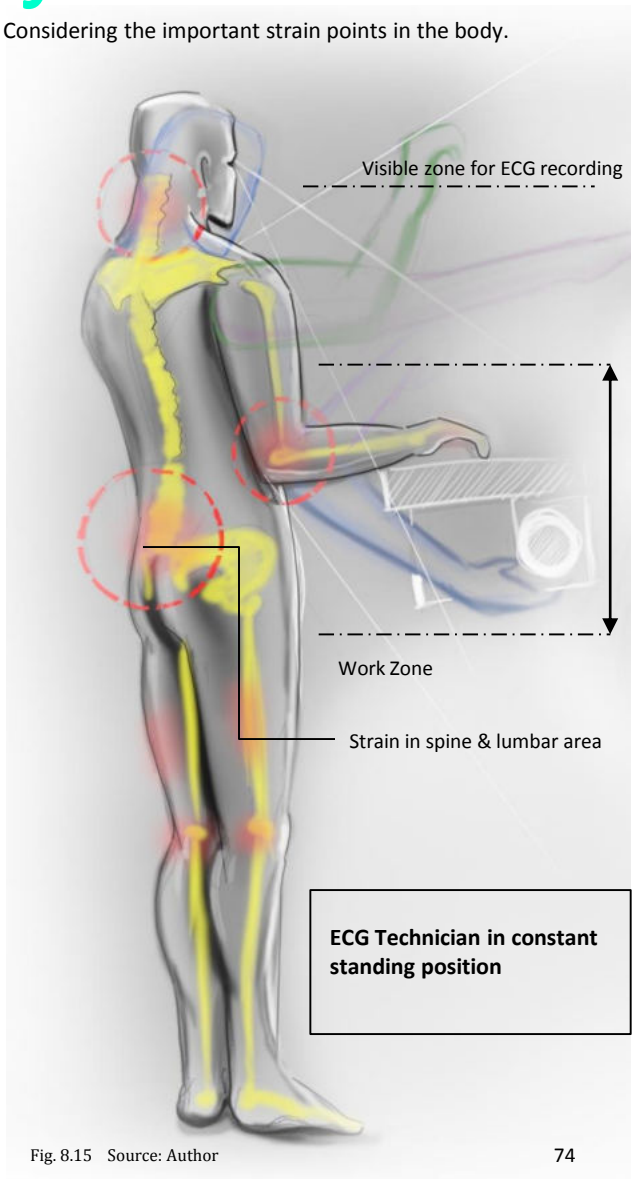


Fig. 8.15 Source: Author

09

DESIGN OF SECONDARY PERIPHERAL COMPONENTS

9.1 Design of Sanitizer Container

9.1.1 Brainstorming

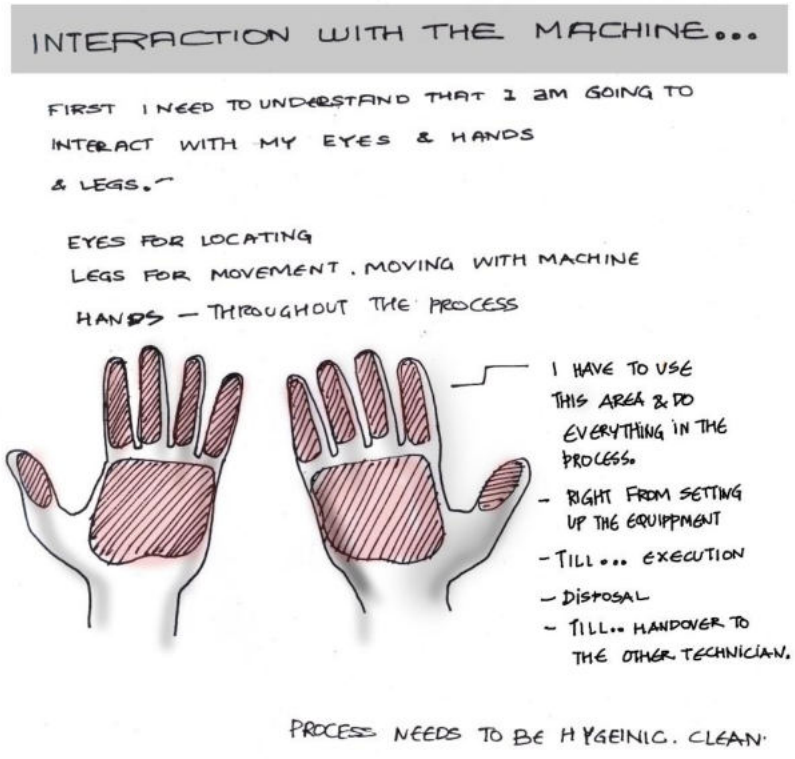


Fig. 9.1 Source: Author

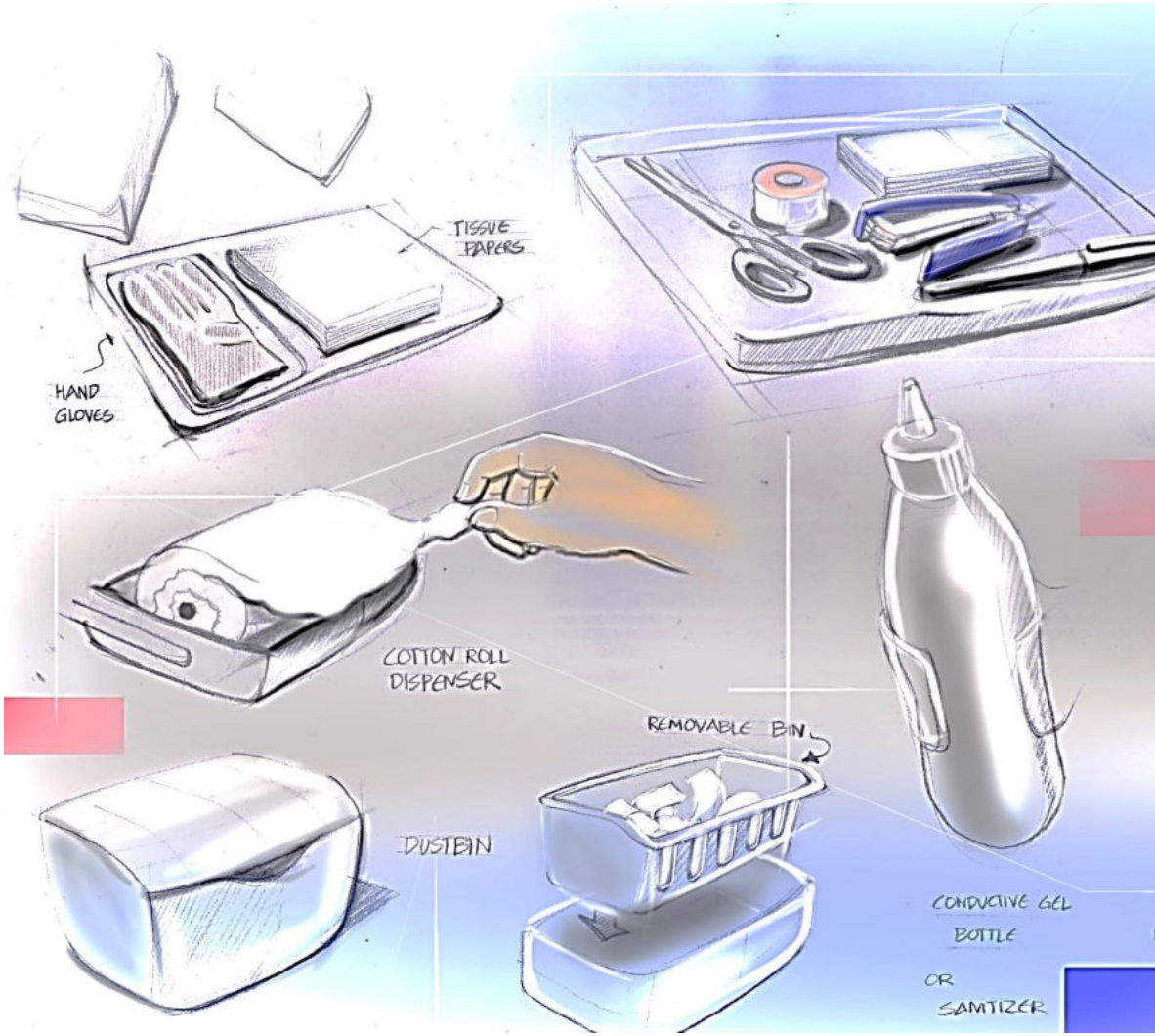


Fig. 9.2 Source: Author

9.1.1 Brainstorming

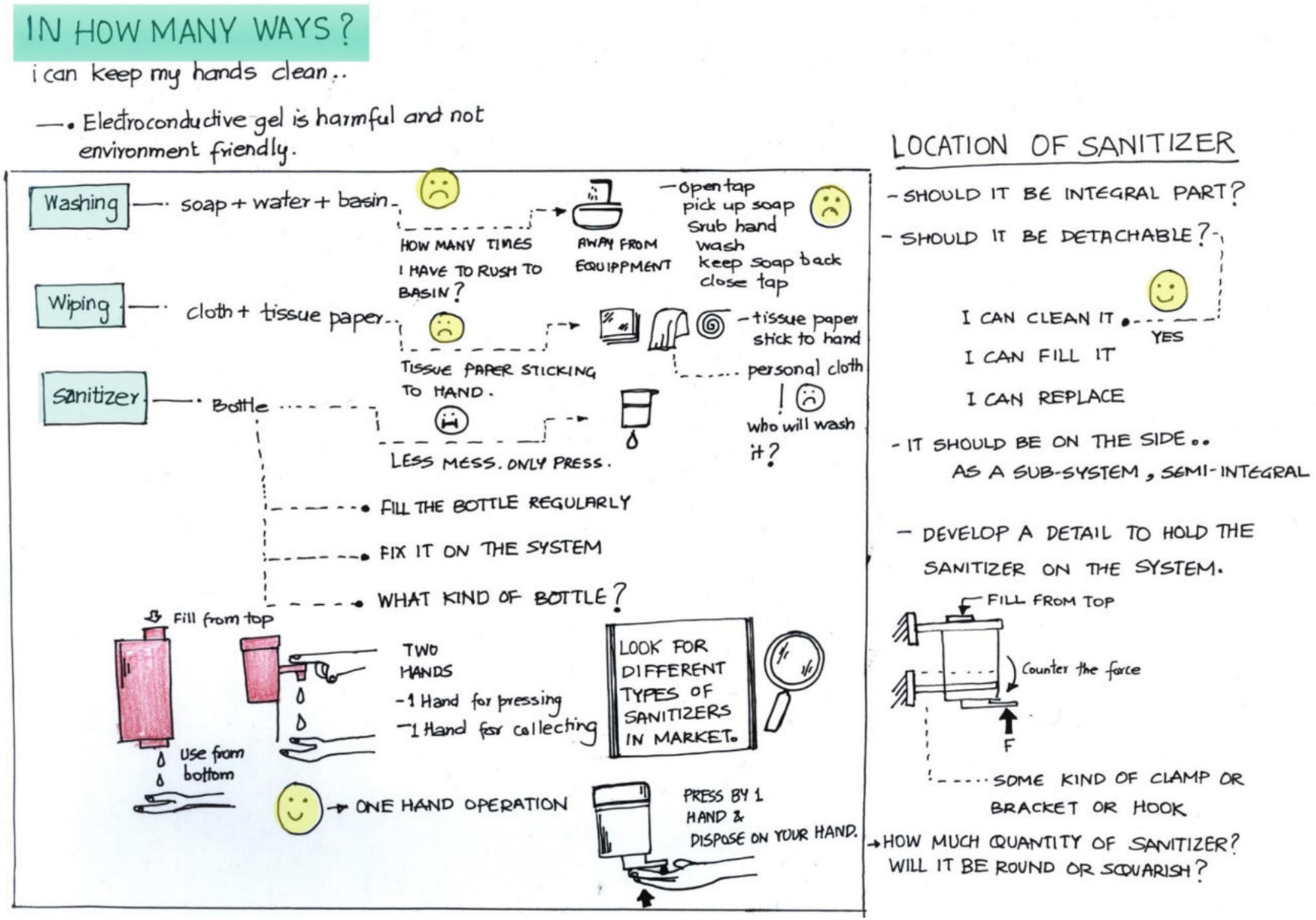
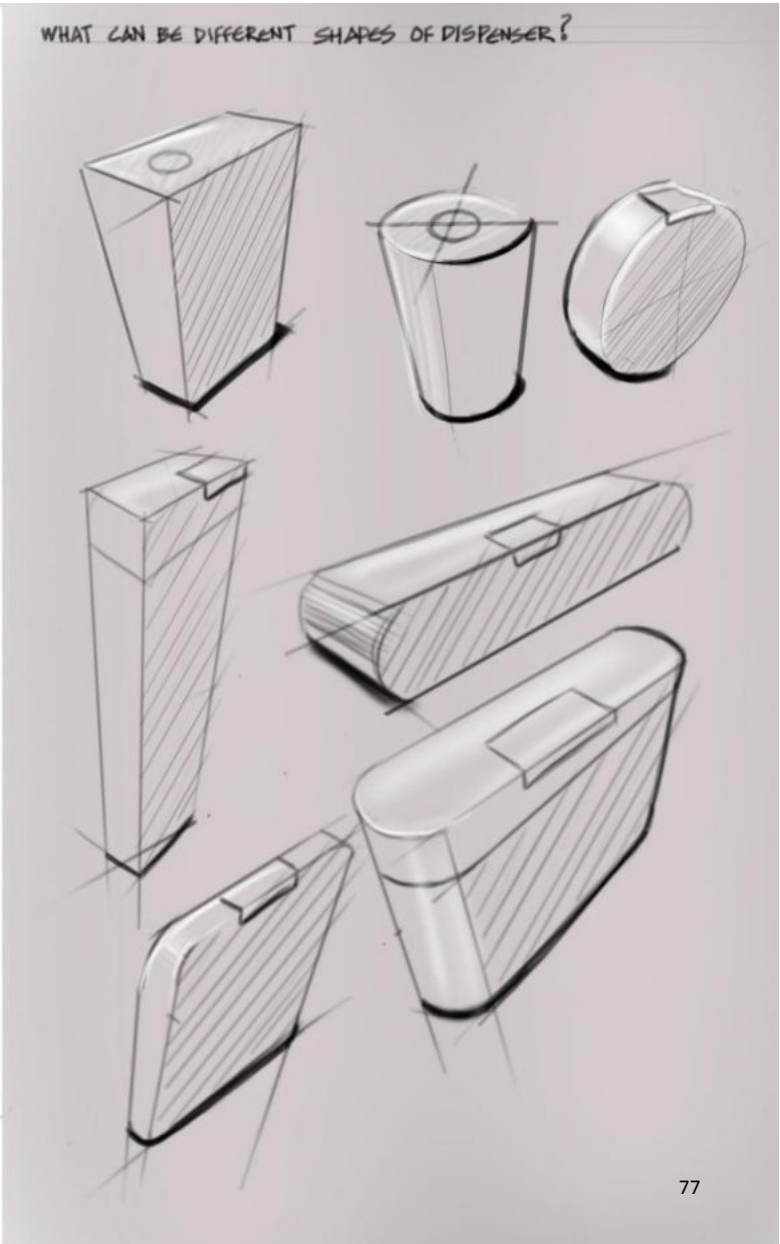


Fig. 9.3 Source: Author

9.1.2 Explorations of different sanitizer shapes

Although the sanitizer can be bought from the market as a bought out item, as a Industrial design student I was curious to find out every design opportunity. Whether this Sanitizer container can become an accessory item for developing a business model

Fig. 9.4 Source: Author



9.1.3 Ideations

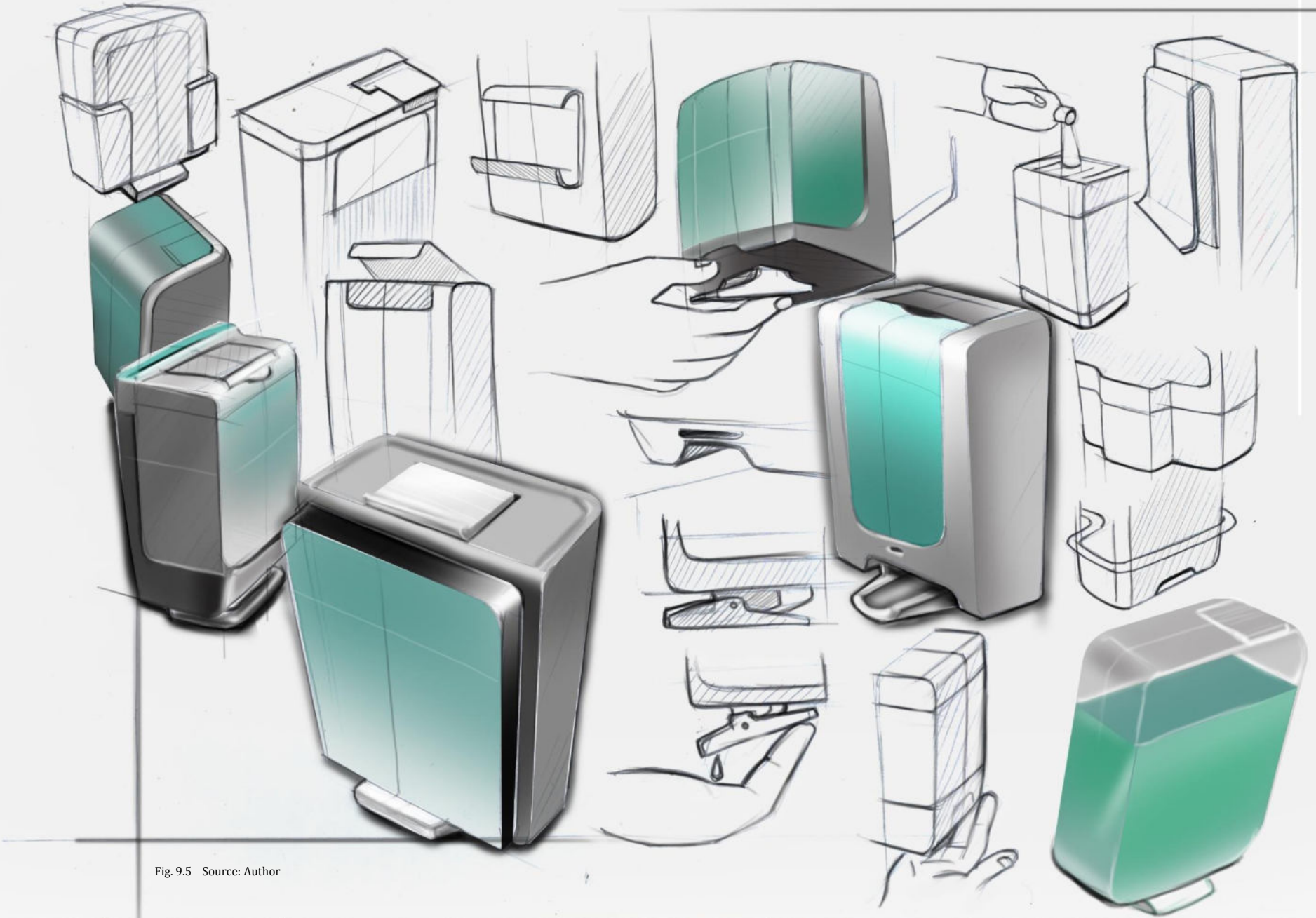


Fig. 9.5 Source: Author

9.1.3 Concept

Pic. 9.6 Source: Author

Sanitizer Box Design

9.2 Design of Dustbin (utility box)

9.2.1 Brainstorming

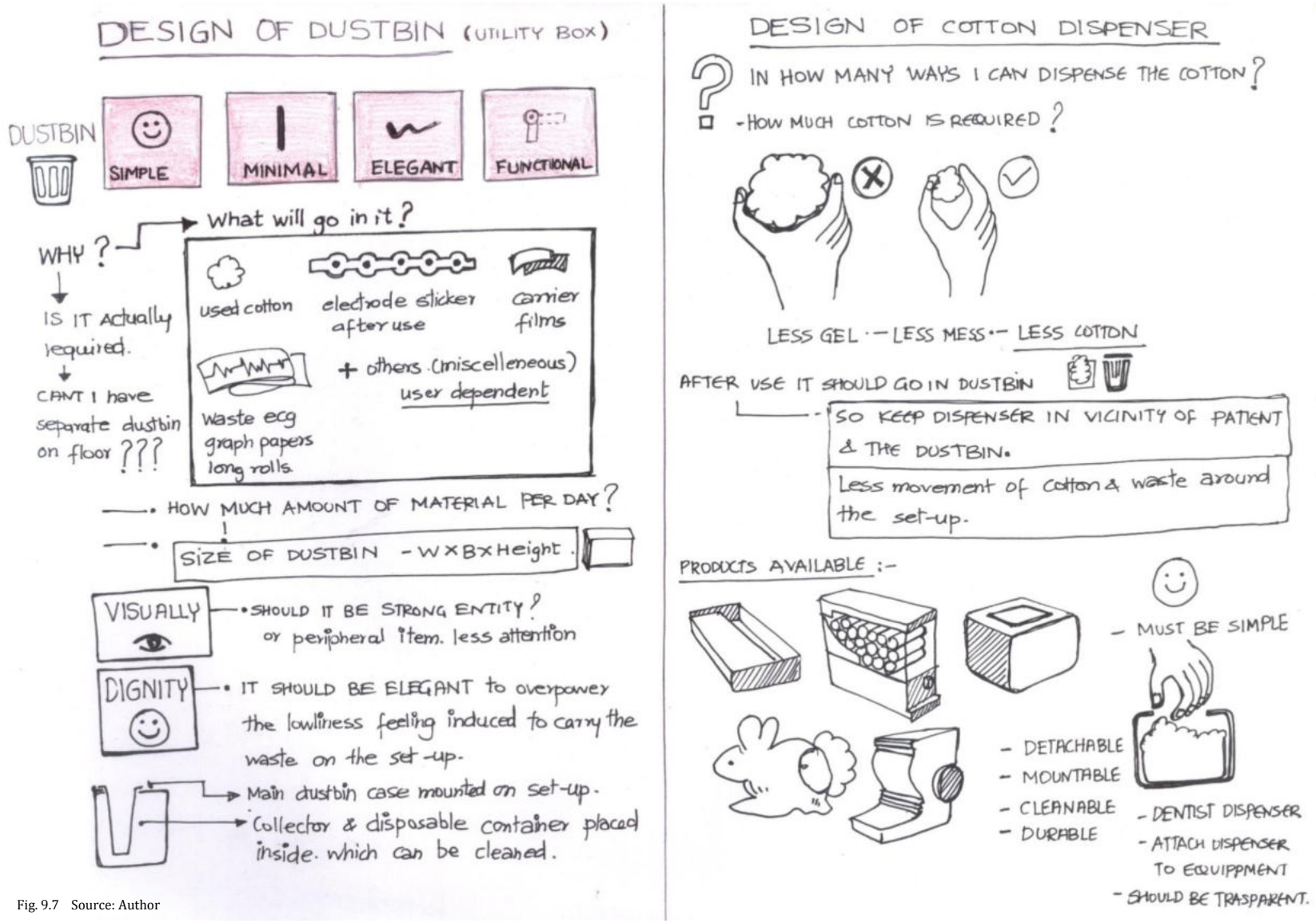


Fig. 9.7 Source: Author

9.2.2 Early Ideations

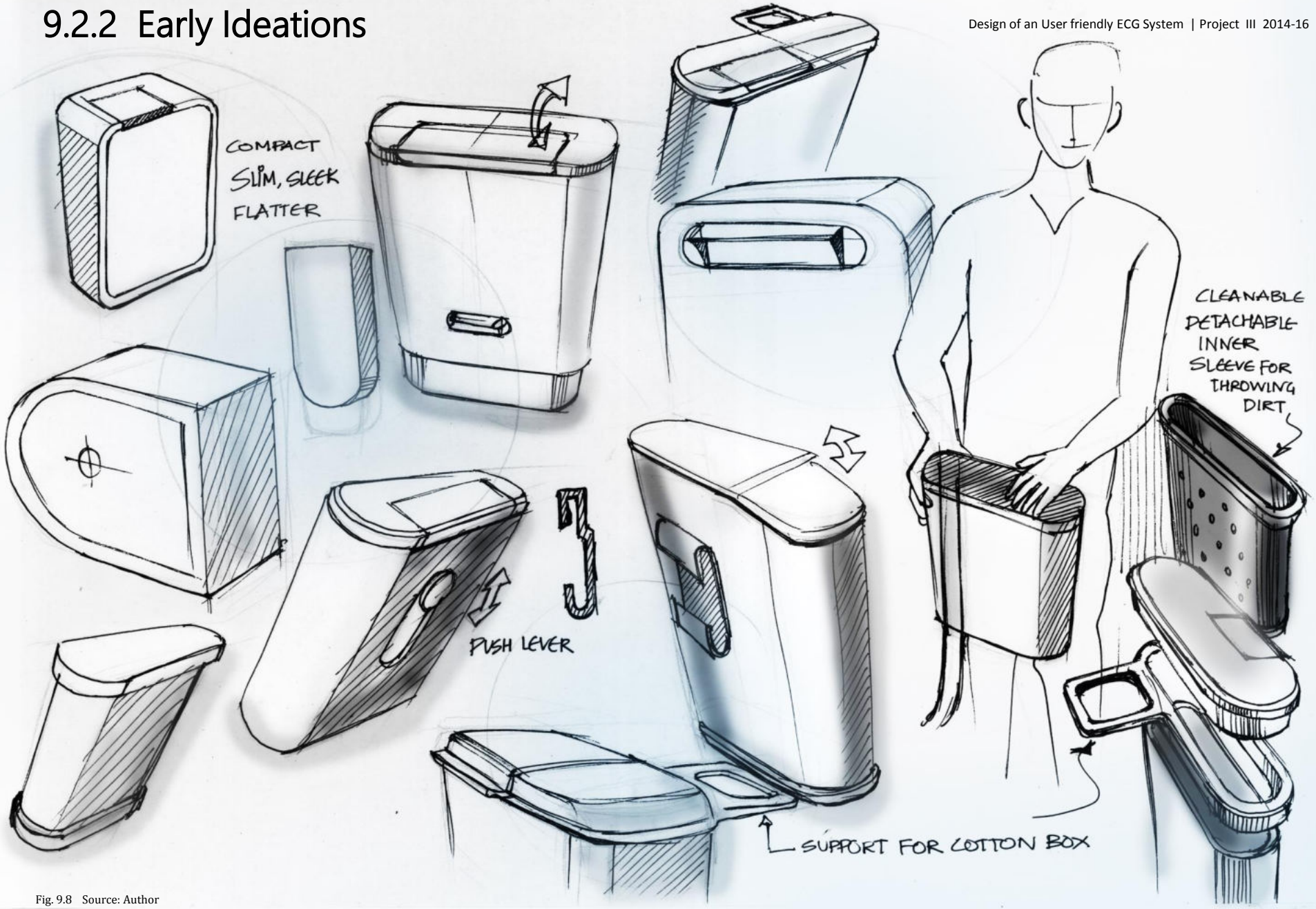
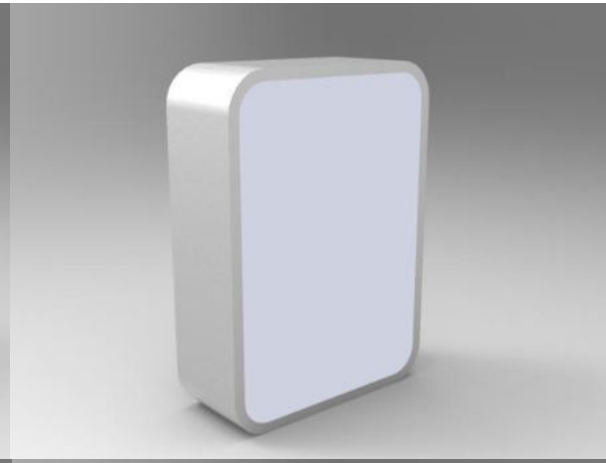


Fig. 9.8 Source: Author

9.2.3 Concept

Various options of dustbins were explored to make it look sleek, compact and minimal.



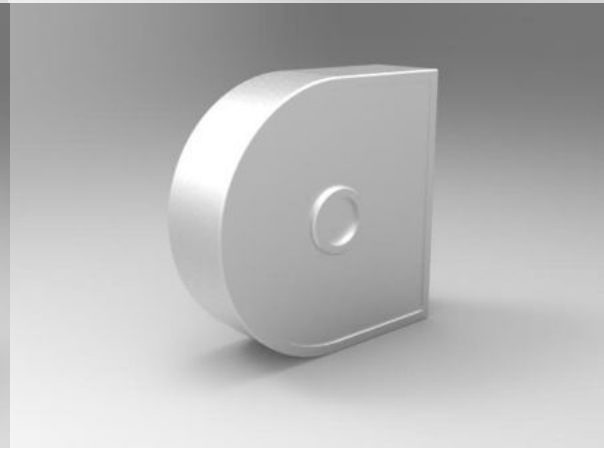
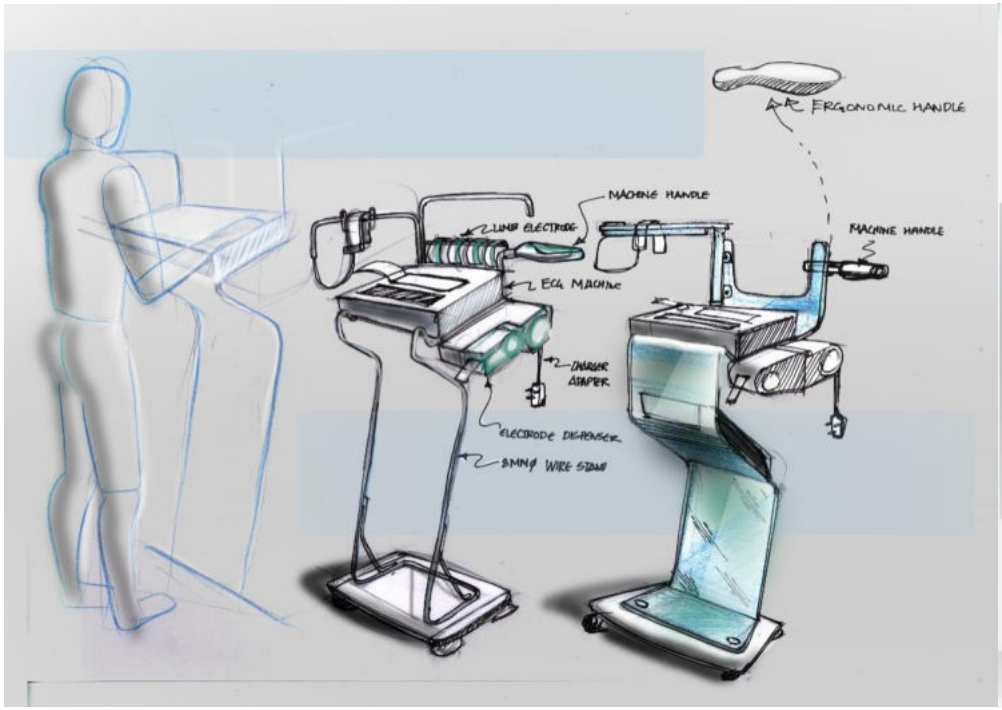


Fig. 9.9 Source: Author

10 DESIGN OF ECG TROLLEY SYSTEM

10.1 Design of Trolley

Various options were explored considering the factors of usability and user centric approach



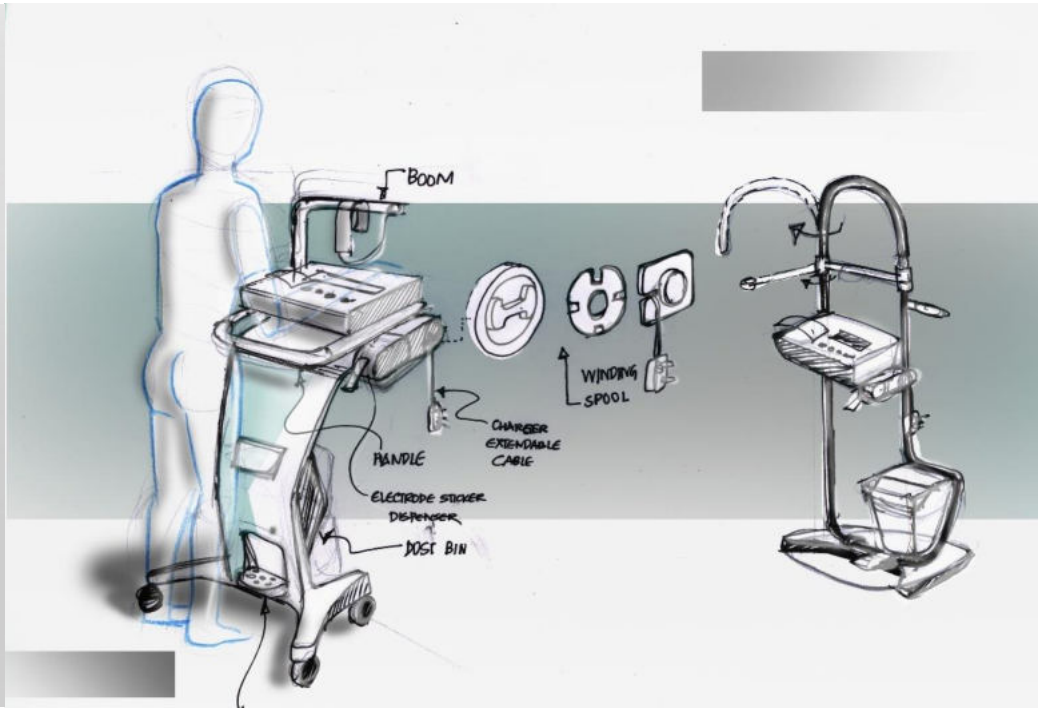


Fig. 10.1 Source: Author

10.1.2 Early Ideations

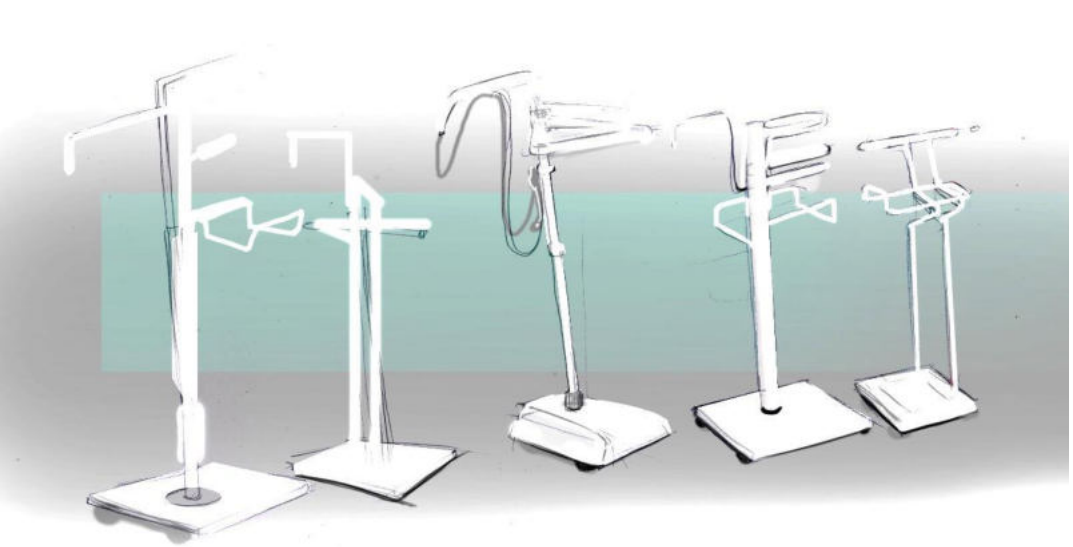
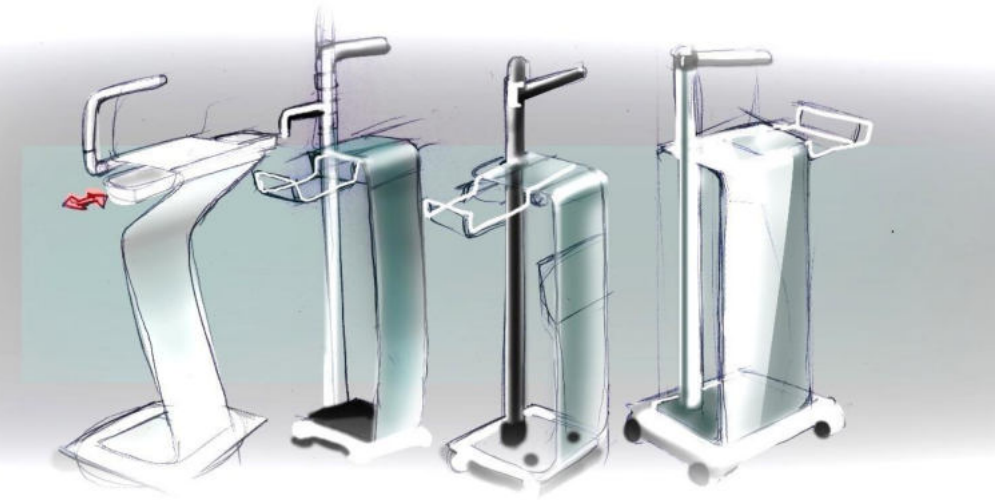


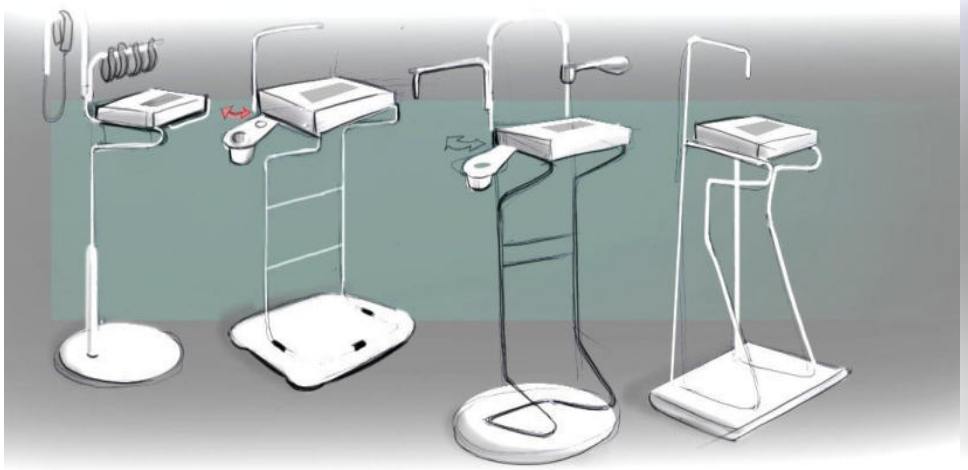
Fig. 10.2 Source: Author

10.1.2 Early Ideations

Fig. 10.3 Source: Author

10.1.2 Early Ideations





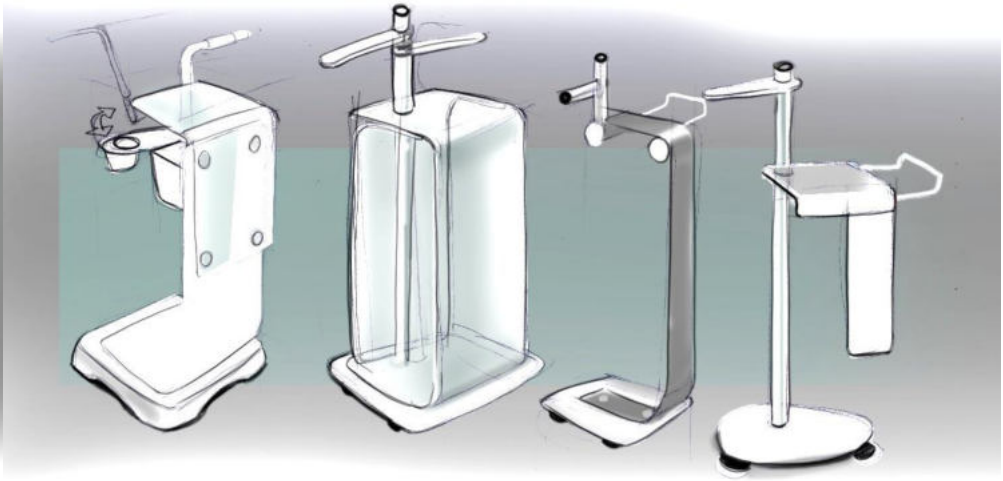


Fig. 10.4 Source: Author

10.1.3 Selection of a design language

SKELETAL

MINIMAL

Visual treatment – thin structure

Visual treatment – pipe structure

MASSIVE

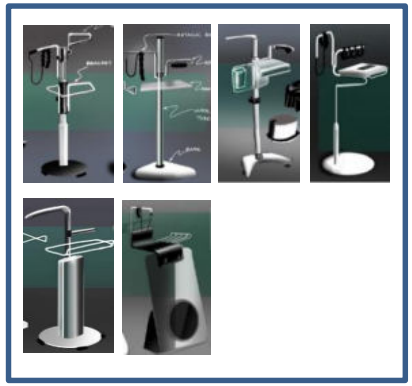
VISUAL MASS

Visual treatment - more mass. bulky

EXECUTIVE

FORMAL

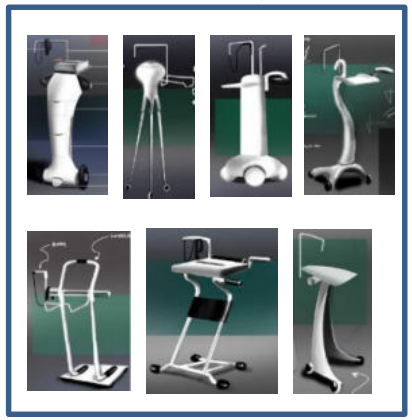
Visual treatment – Glass & metal



MODERN

URBAN

Visual treatment – bulked up structure



Skeletal structural language was selected for further refinement

10.1.4 Steering of the trolley system

Various approaches for steering & handling the system were thought about. In how many ways can I handle & steer the system.

What kind of handle system will work semantically for a medical grade product.

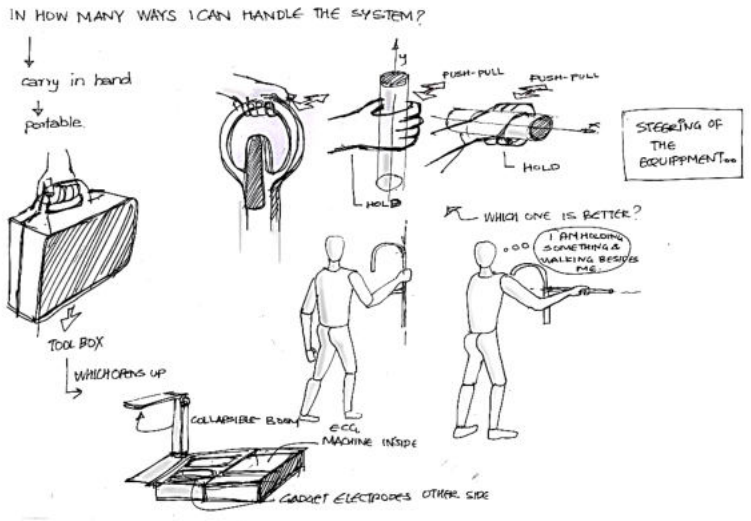


Fig. 10.5 Source: Author

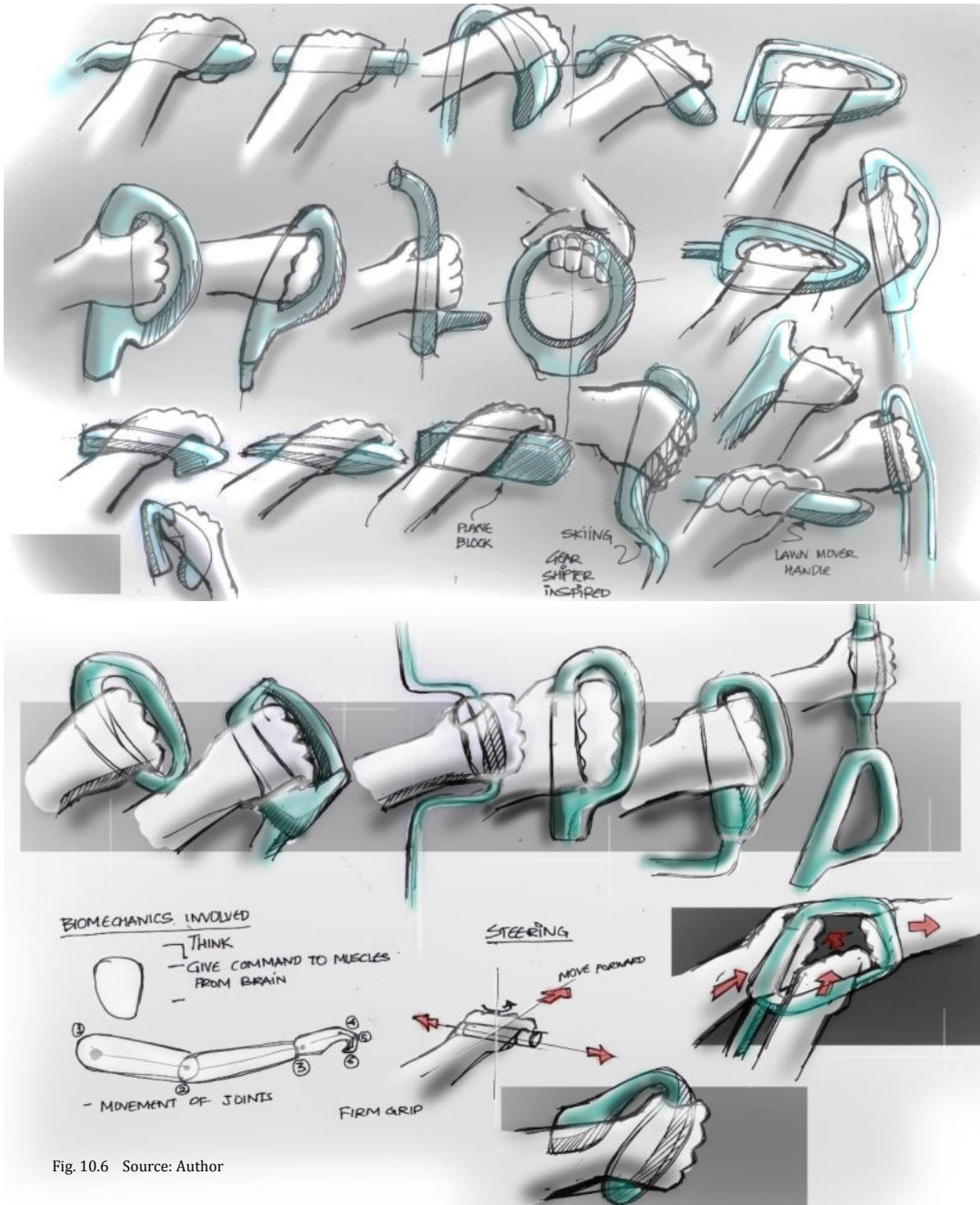


Fig. 10.6 Source: Author

10.1.5 Iterations of the structure

A radically different approach was used to come up with different iterations of trolley structures which eventually got filtered to some lean & mean structures.

The use of alphabets were done to derive different combinations of the structure.

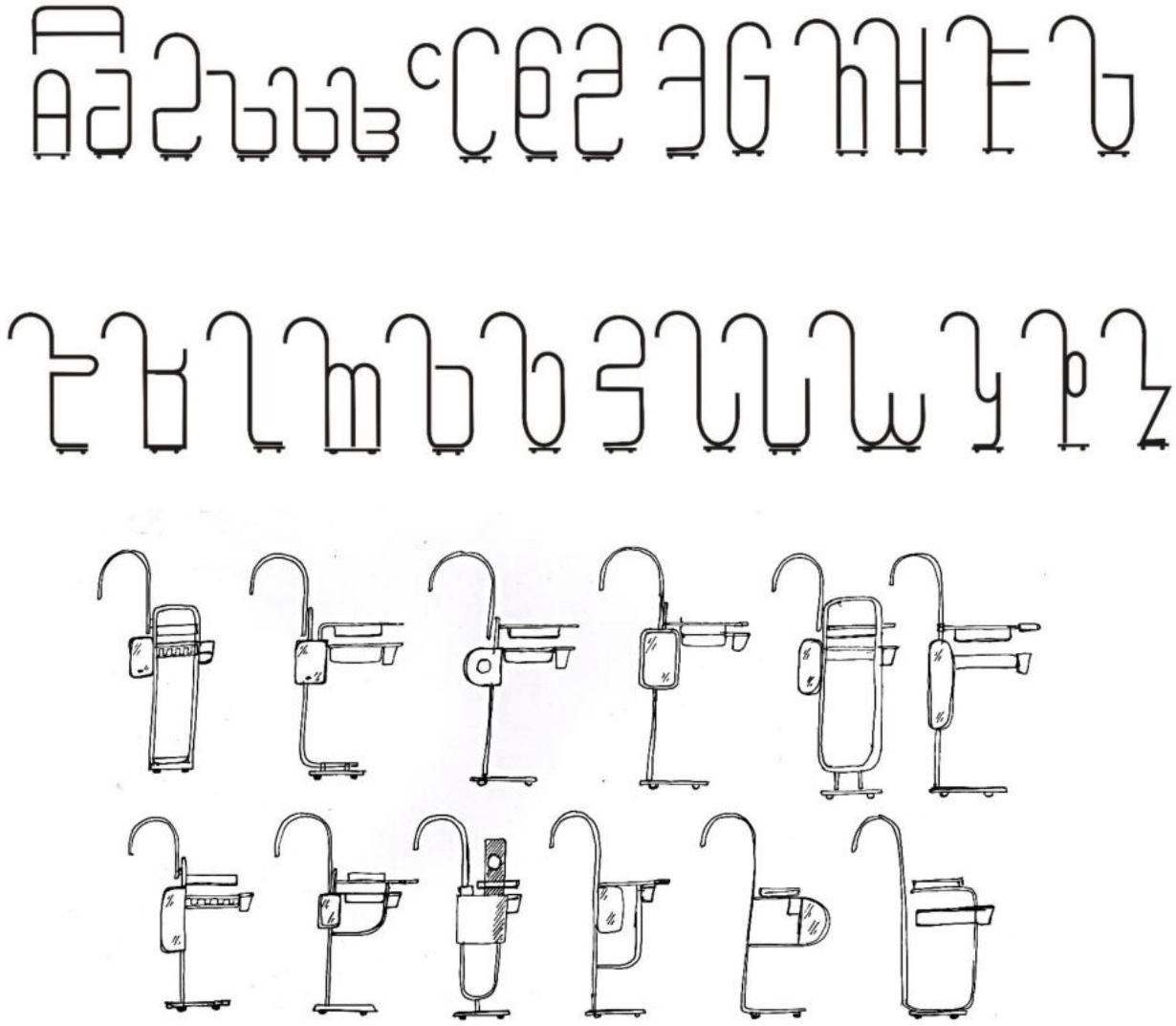


Fig. 10.7 Source: Author

10.1.6 Trolley Arrangement

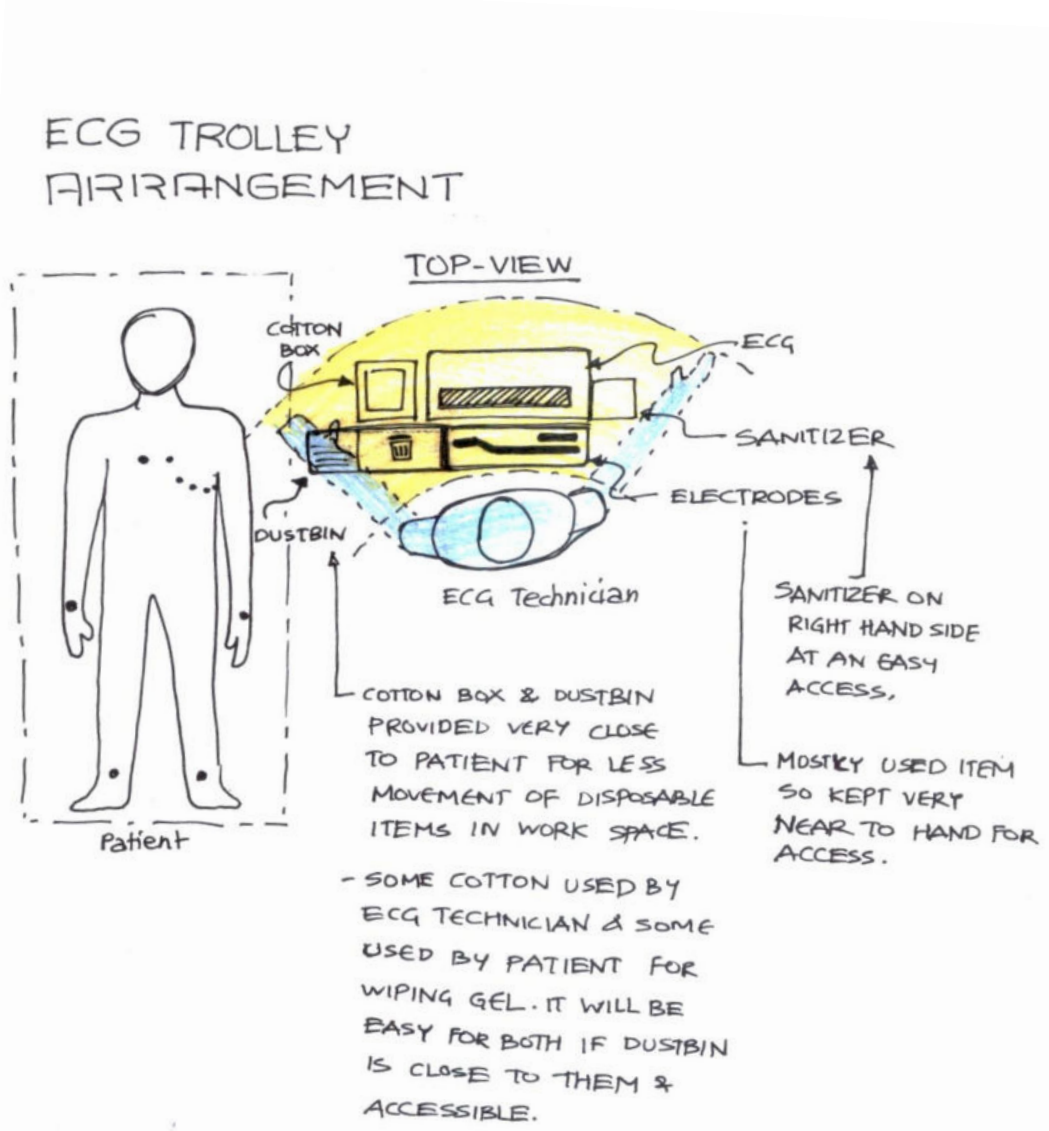


Fig. 10.8 Source: Author

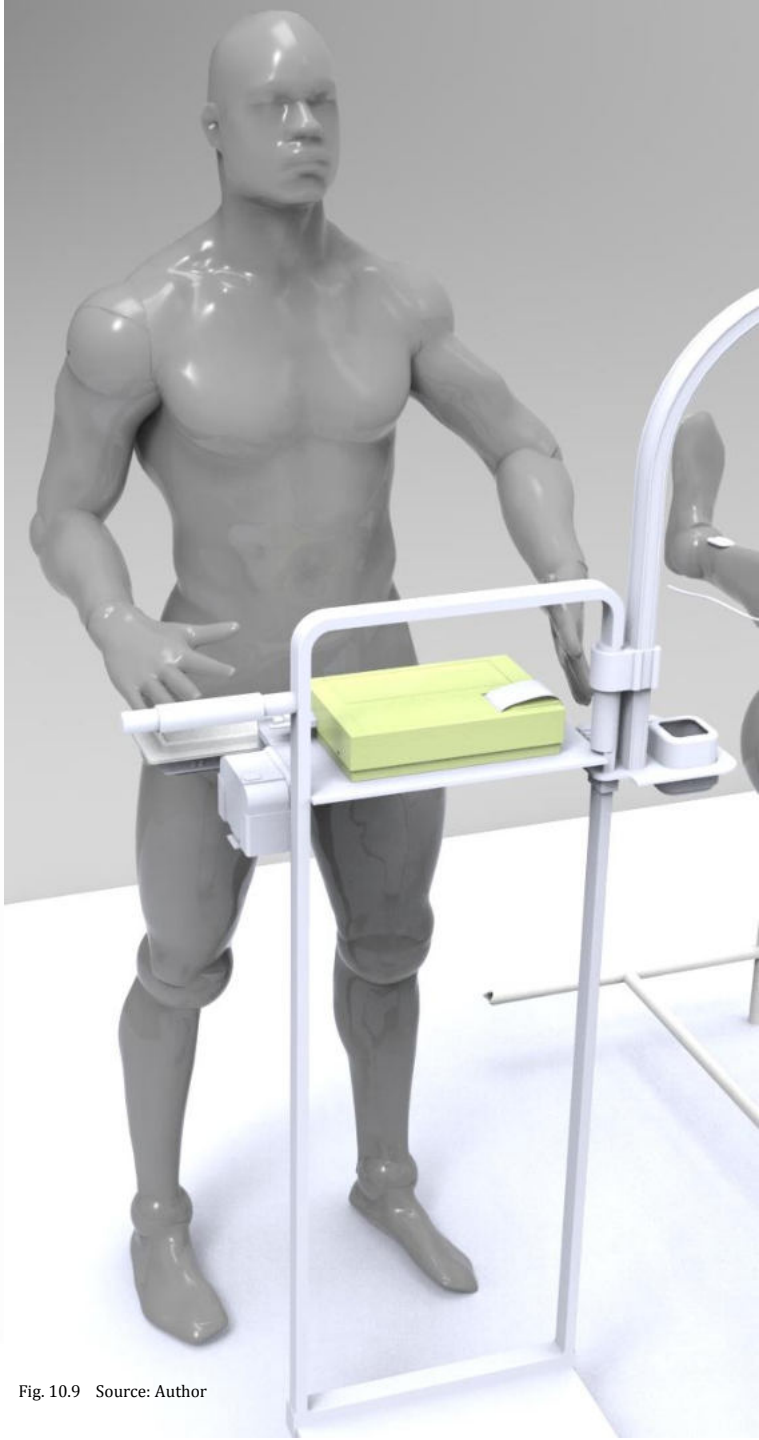


Fig. 10.9 Source: Author

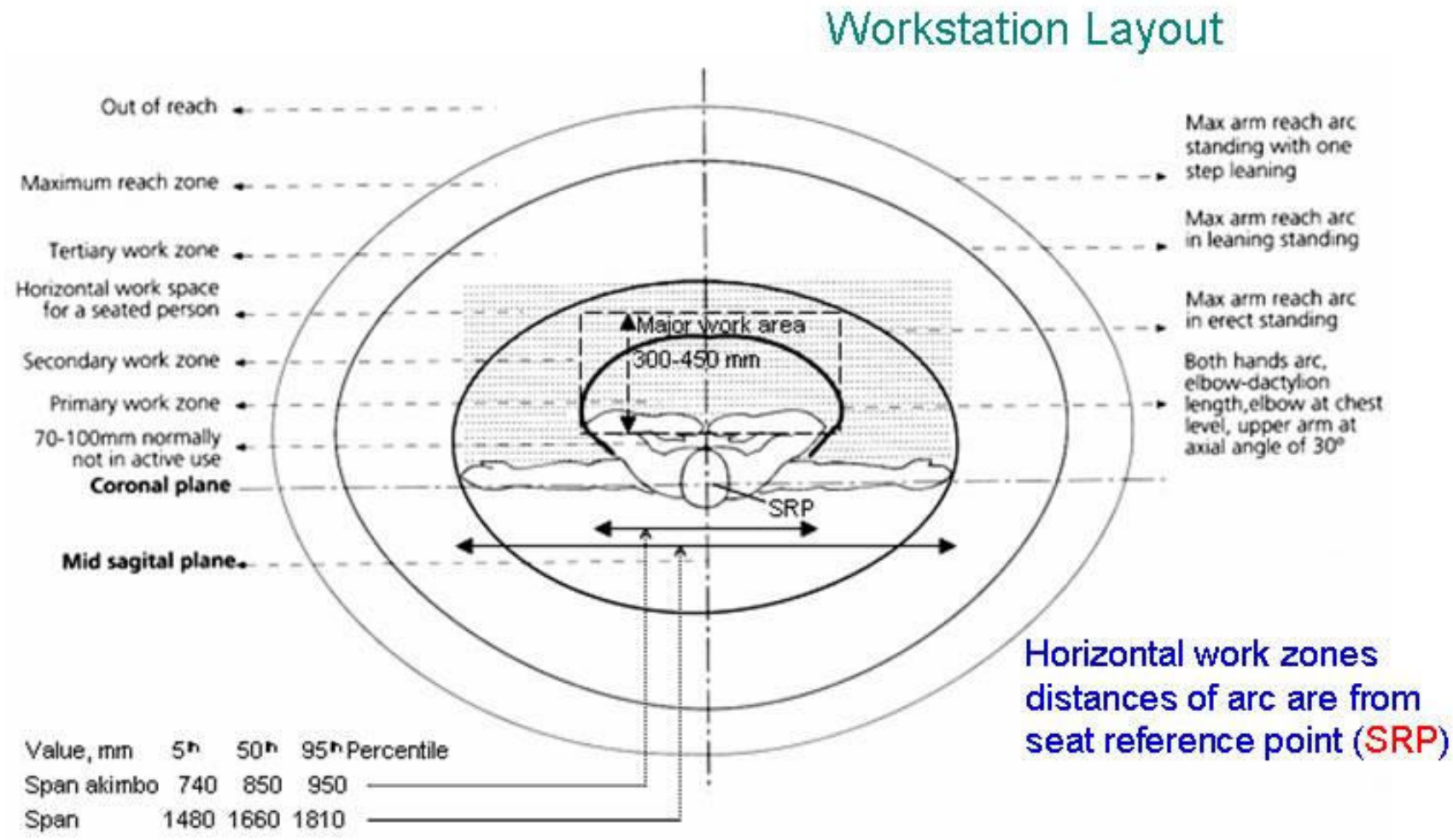


Fig. 10.10 Source: Ref : " Horizontal work surface at around elbow height", Sakshat Virtual Lab, IITG

Work surface Height for Varied Work Levels

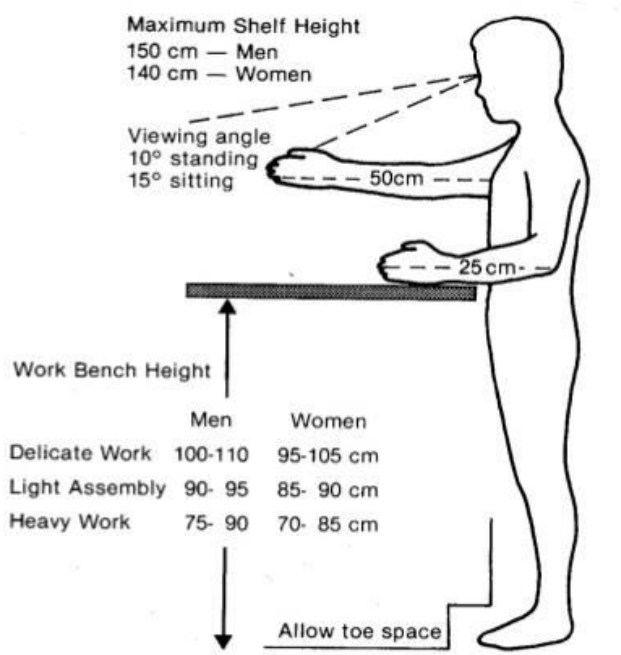


Fig. 10.11 Source: Ref : arido-ergonomics-amp-design-by-opc

10.1.7 Ideations for different forms of trolley details

Different base options with different shapes were ideated along with some basic form of the structure.

The section of the structure was considered as square mainly to carry a sturdy design language throughout the formation of the structure.

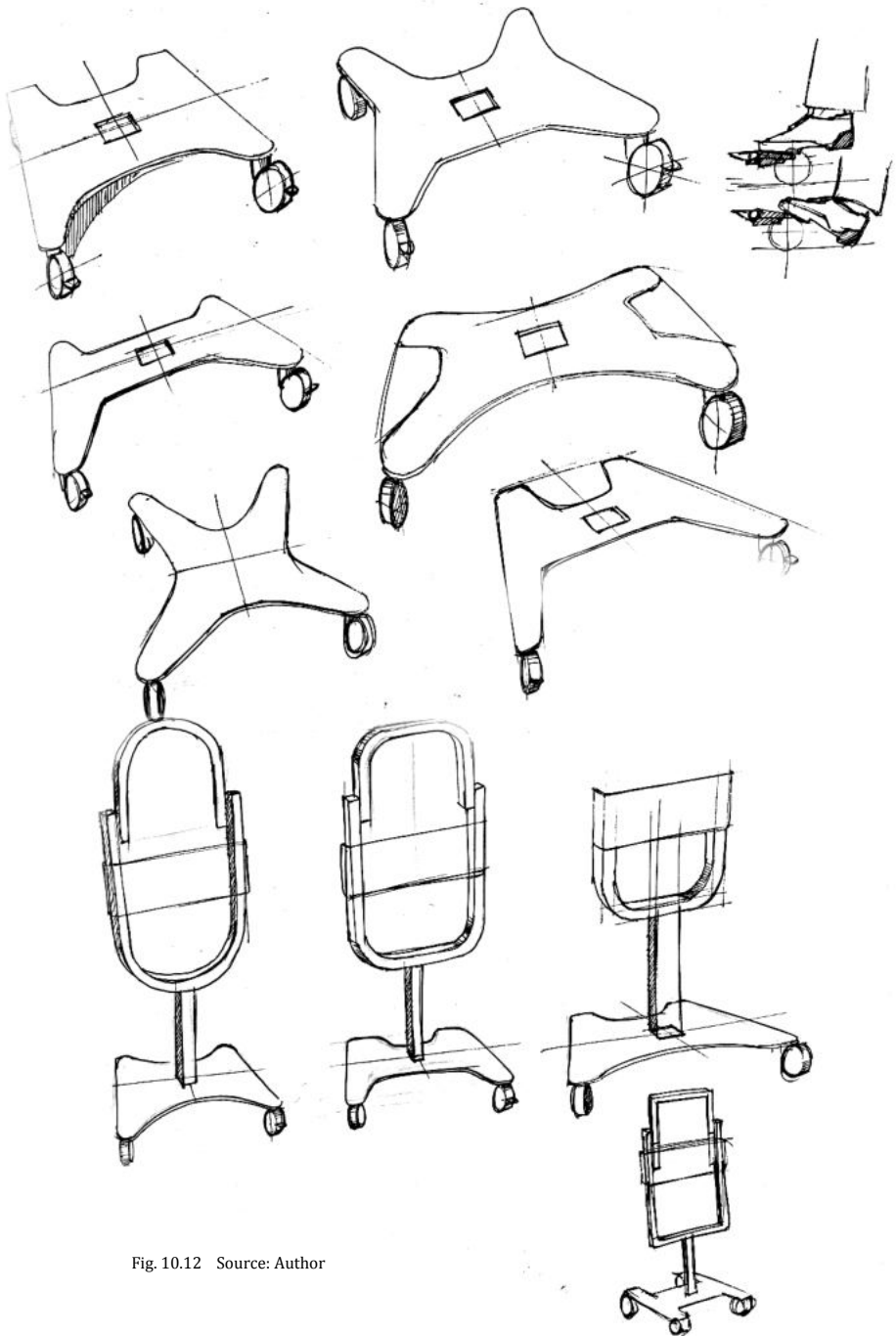


Fig. 10.12 Source: Author

Anthropometric Details

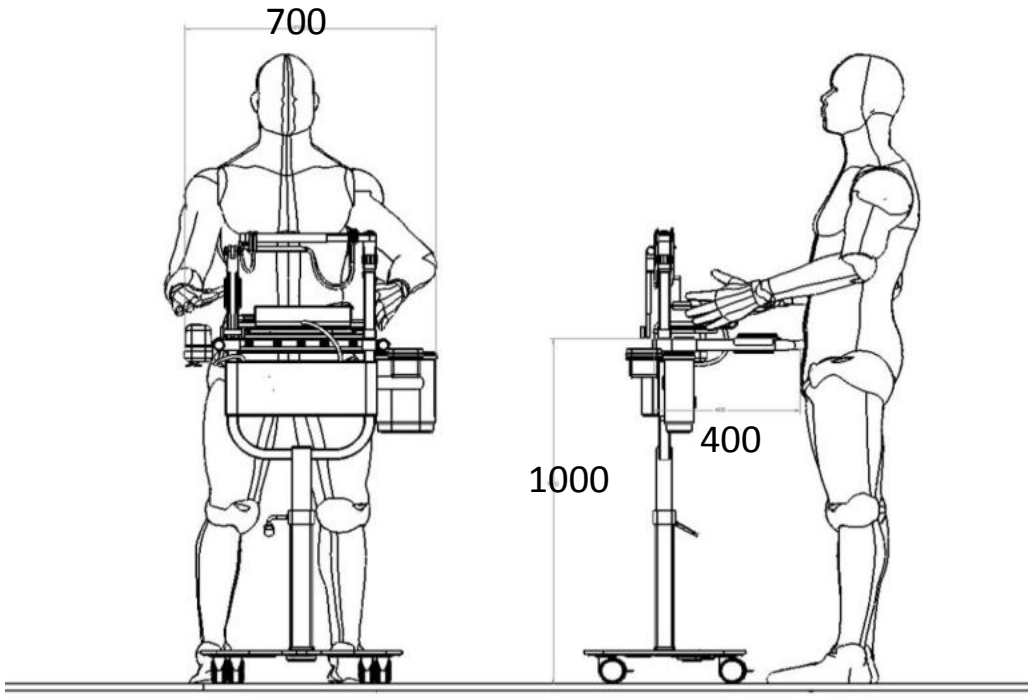


Fig. 10.13 Source: Author

11 CONCEPTS

11.1 Images and Mood Board

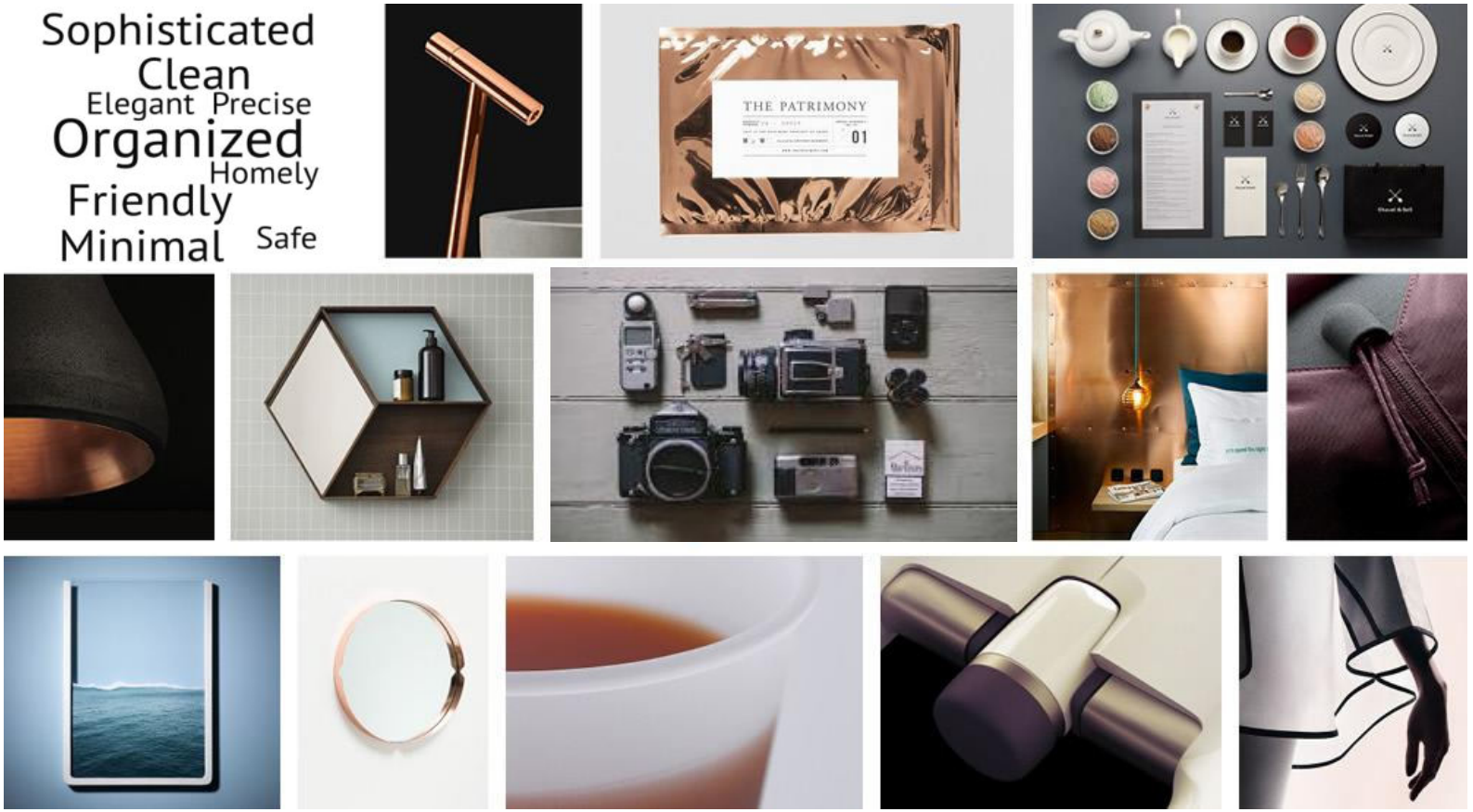
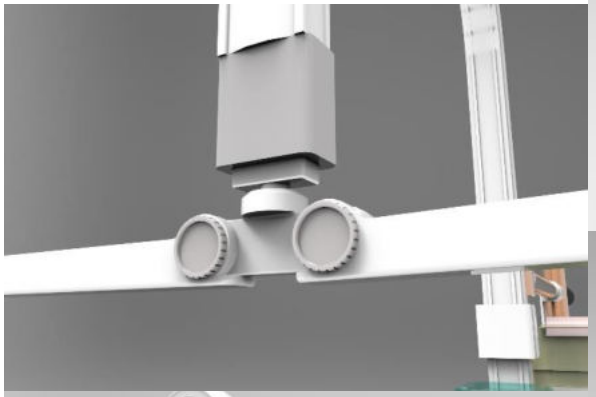


Fig. 11.1 Ref : www.pinterest.com, www.designfather.com

11.1.1 Initial Iterations

Different base options with different shapes were ideated along with some basic form of the structure.

In the initial iterations , the balance of the structure was considered as a main factor in deciding & arriving at the final form of the equipment.



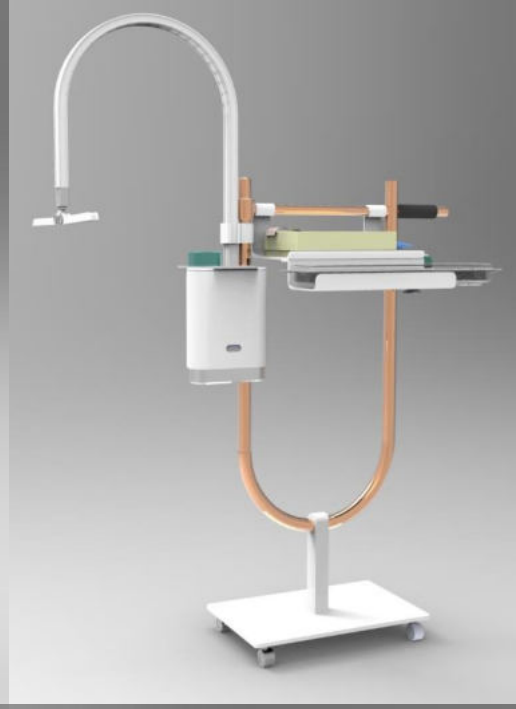


Fig. 11.1 Source: Author

11.2 Renderings Proposed Concepts

Fig. 11.2 Source: Author

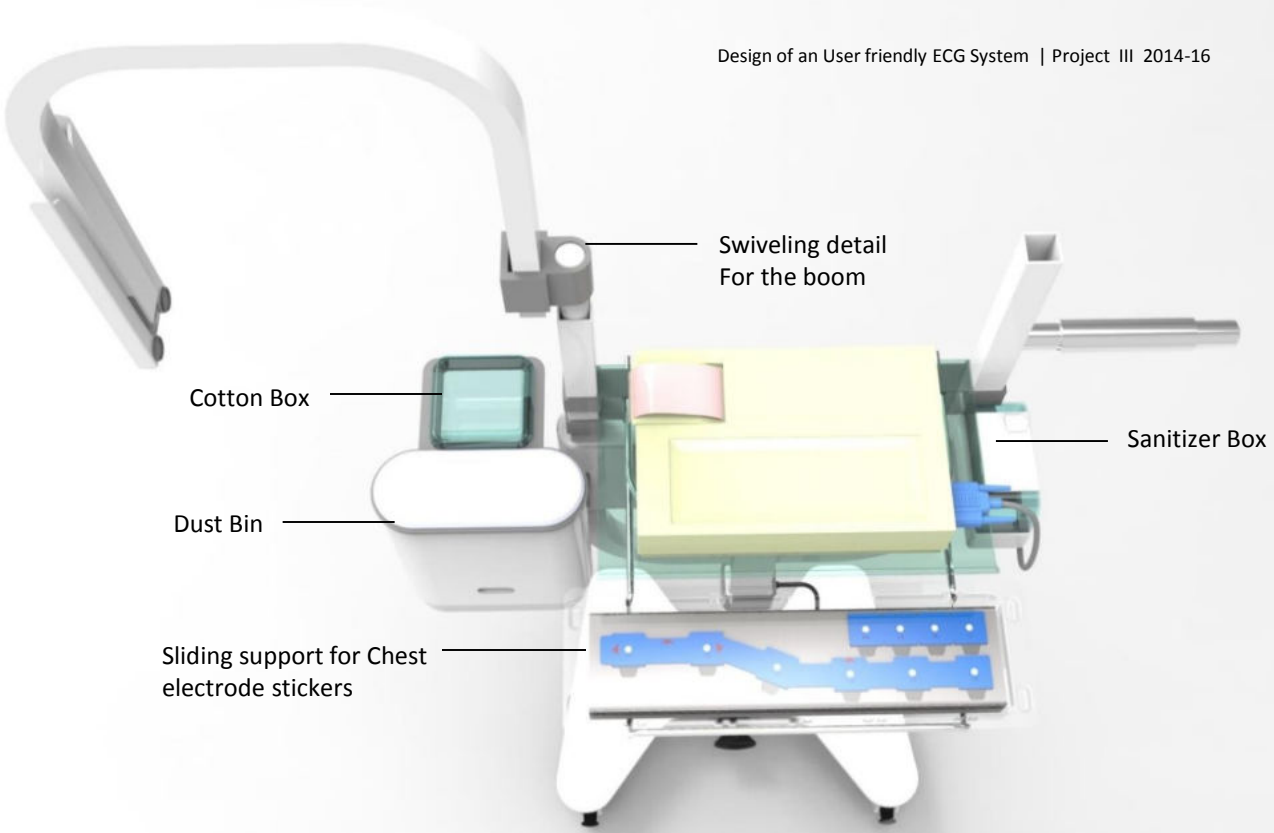
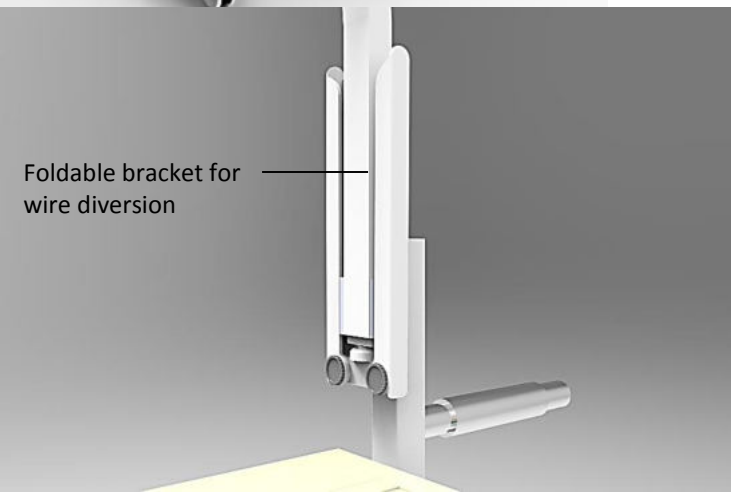
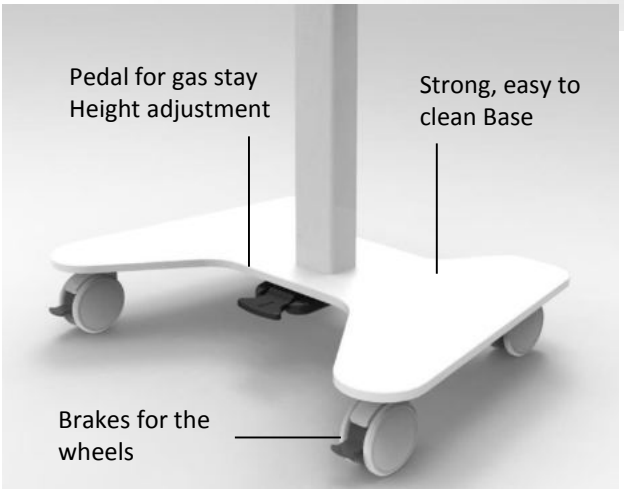
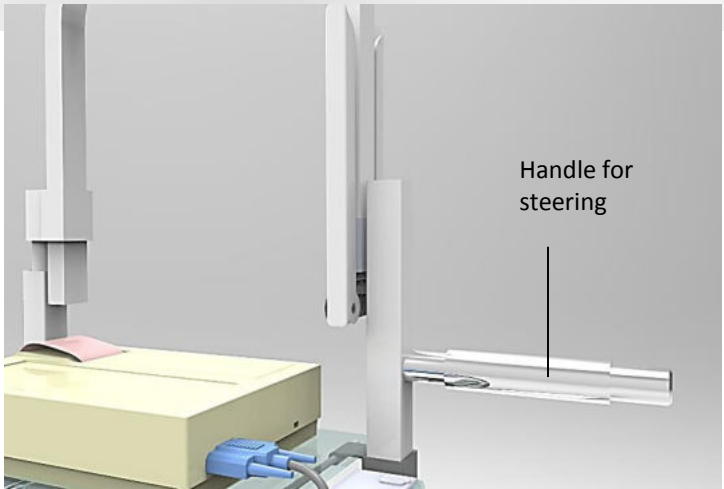


Fig. 11.3 Source: Author







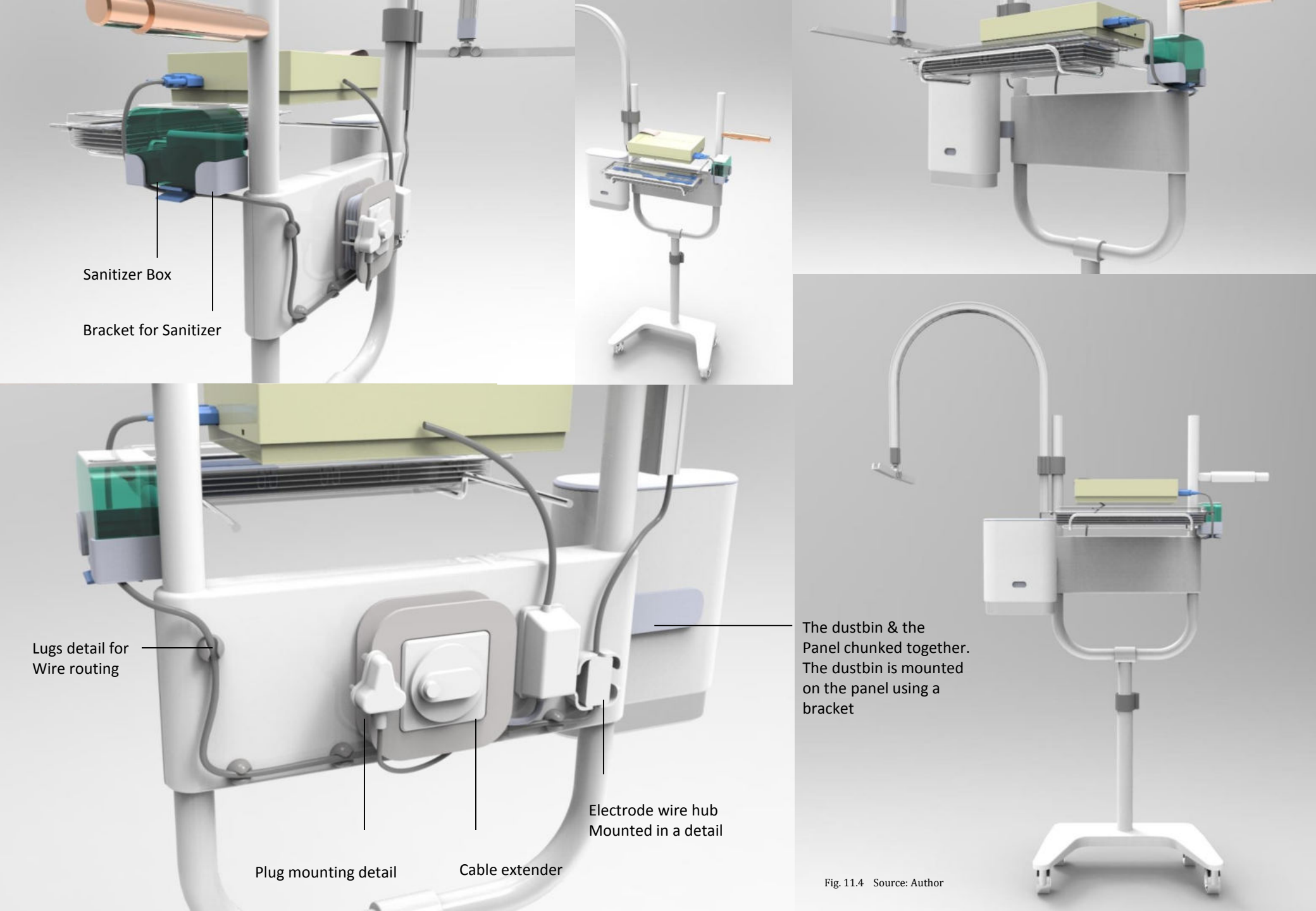


Fig. 11.4 Source: Author

11.2.1 Rendering Concept A Open Condition

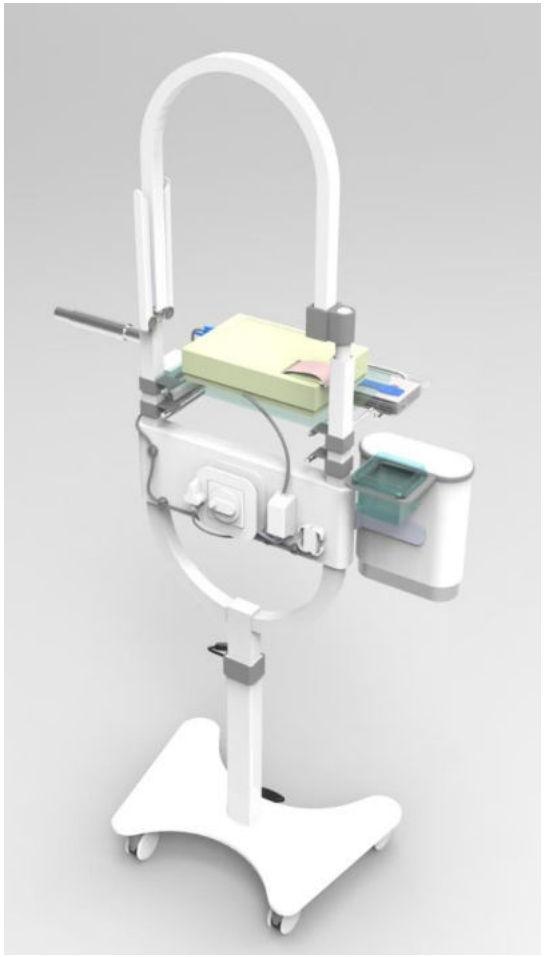


Fig. 11.5 Source: Author

11.2.1 Rendering Concept A Closed Condition

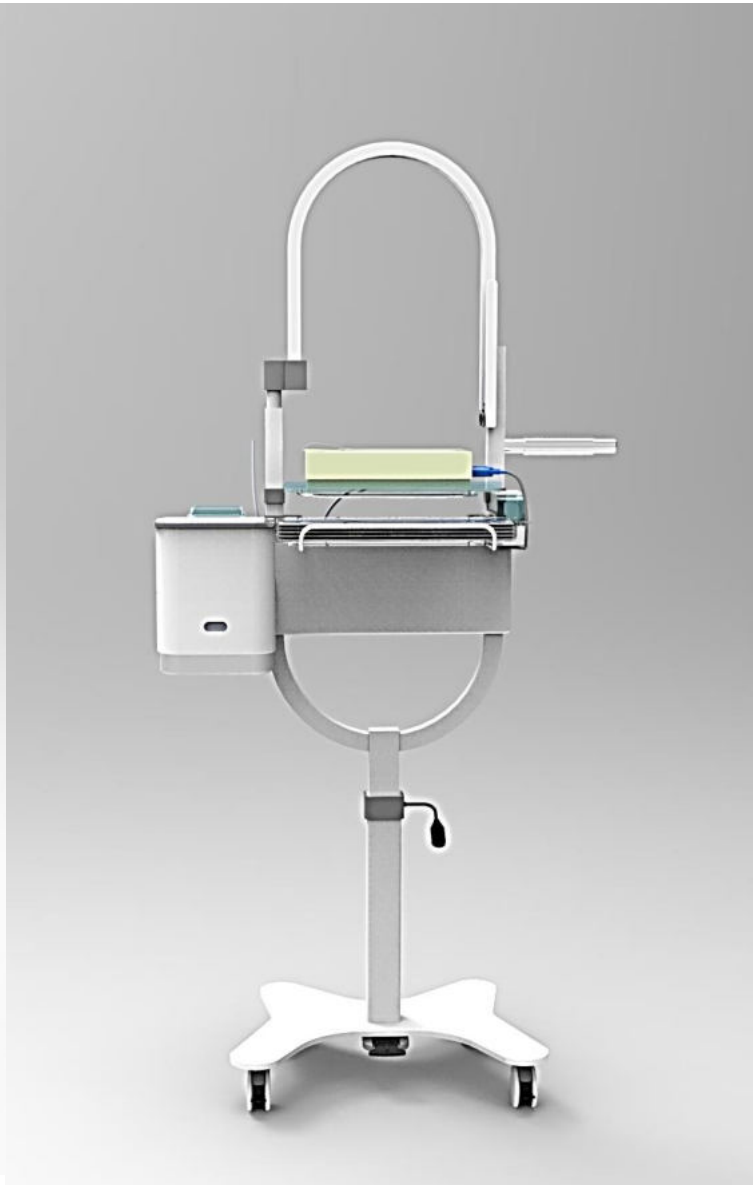


Fig. 11.6 Source: Author

11.2.2 Rendering Concept B Open Condition

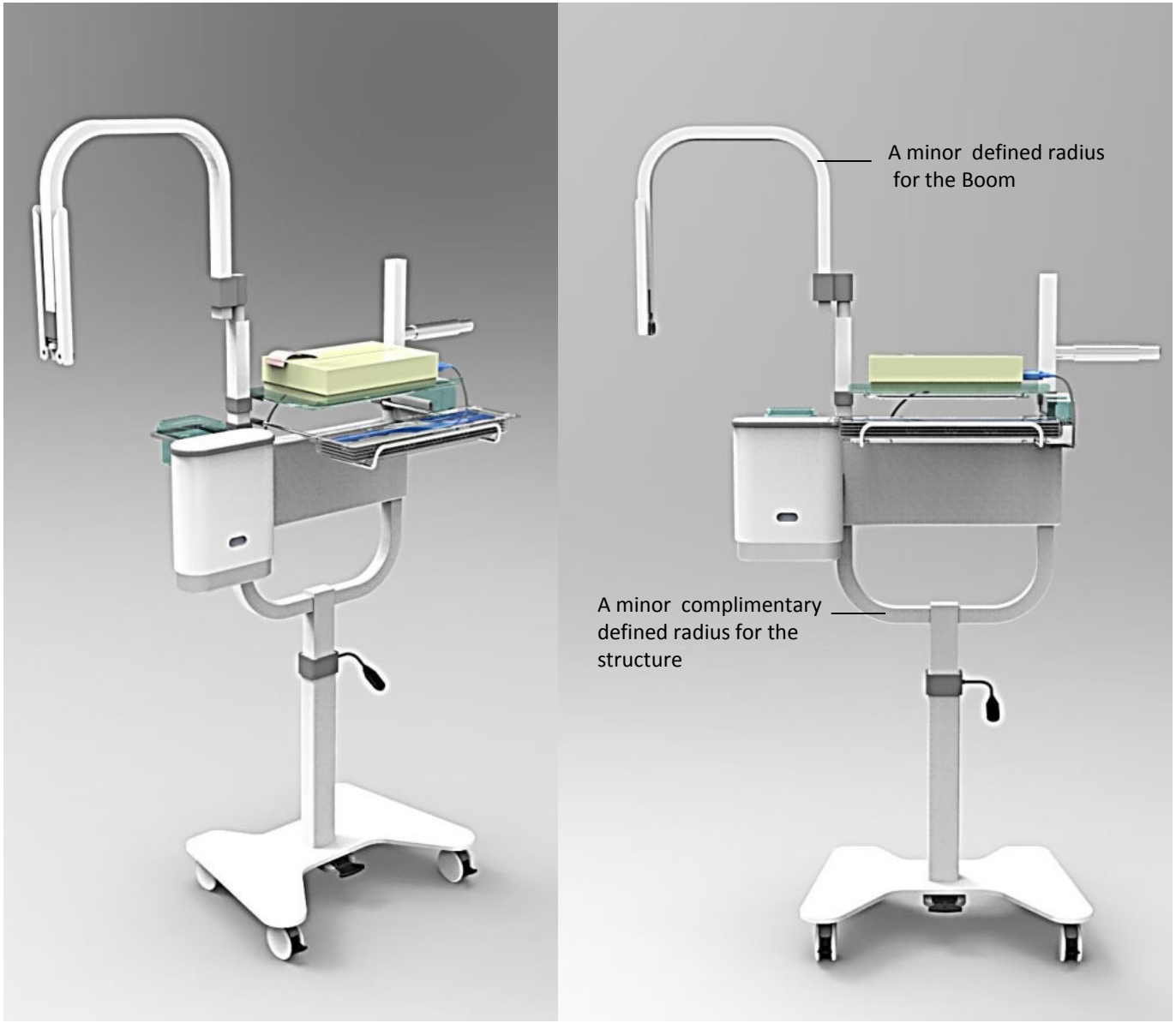
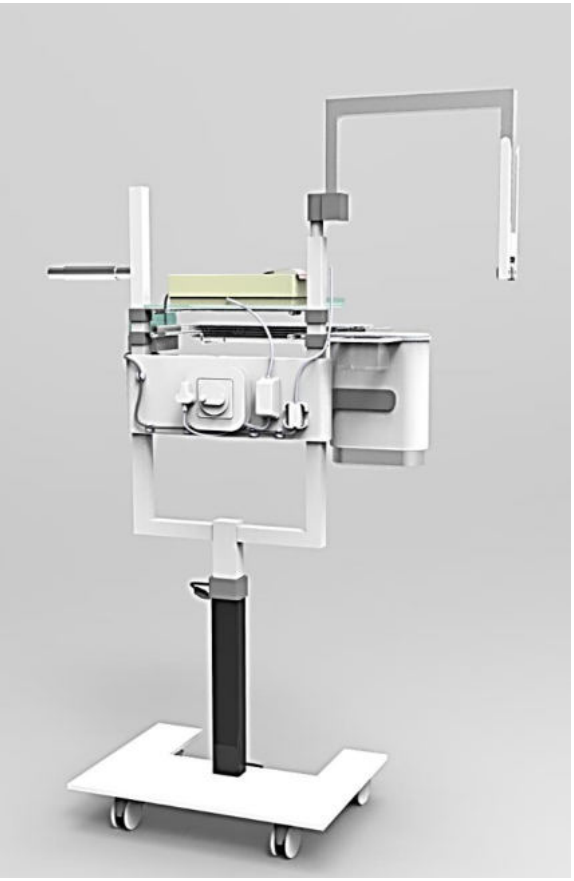


Fig. 11.7 Source: Author

11.2.2 Rendering Concept B Closed Condition

Fig. 11.8 Source: Author

11.2.3 Rendering Concept C Open Condition



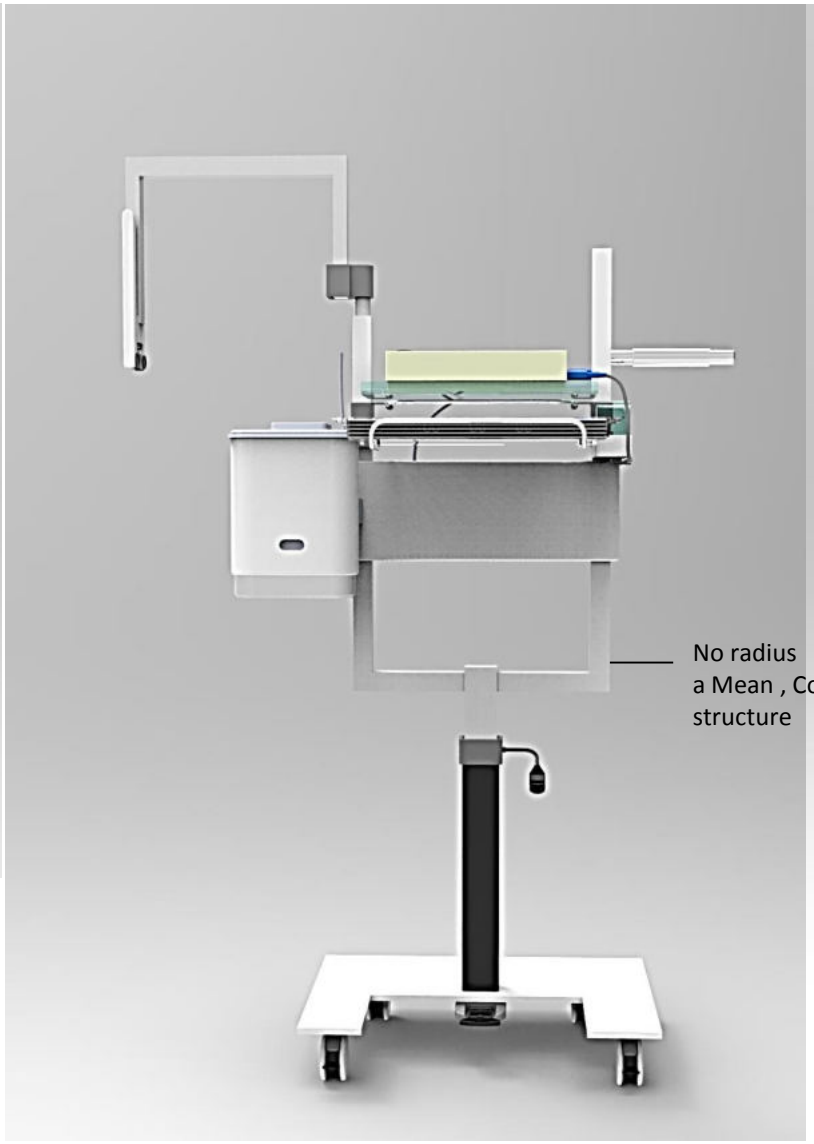


Fig. 11.10 Source: Author

11.2.3 Rendering Concept C Closed Condition

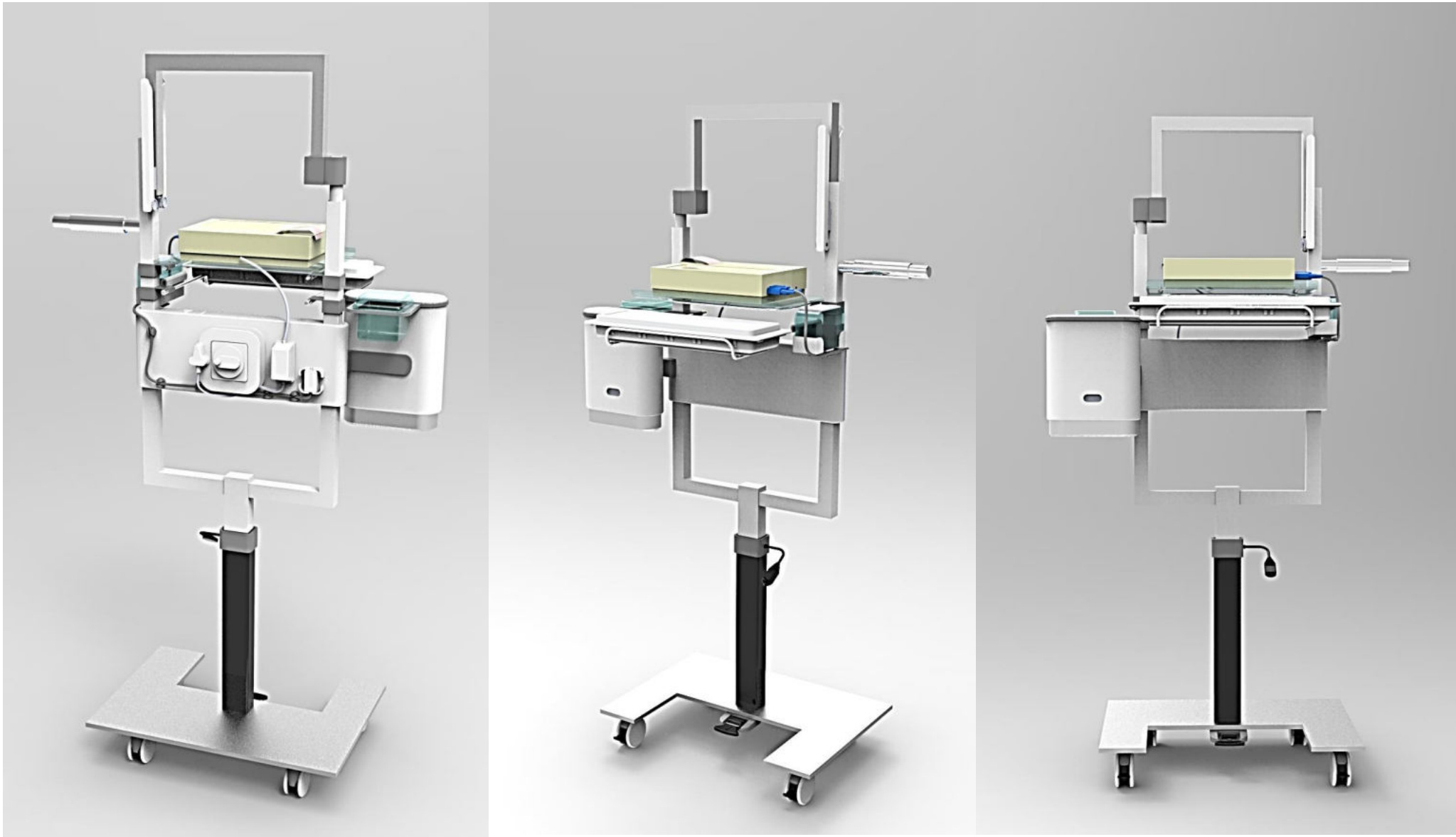


Fig. 11.11 Source: Author

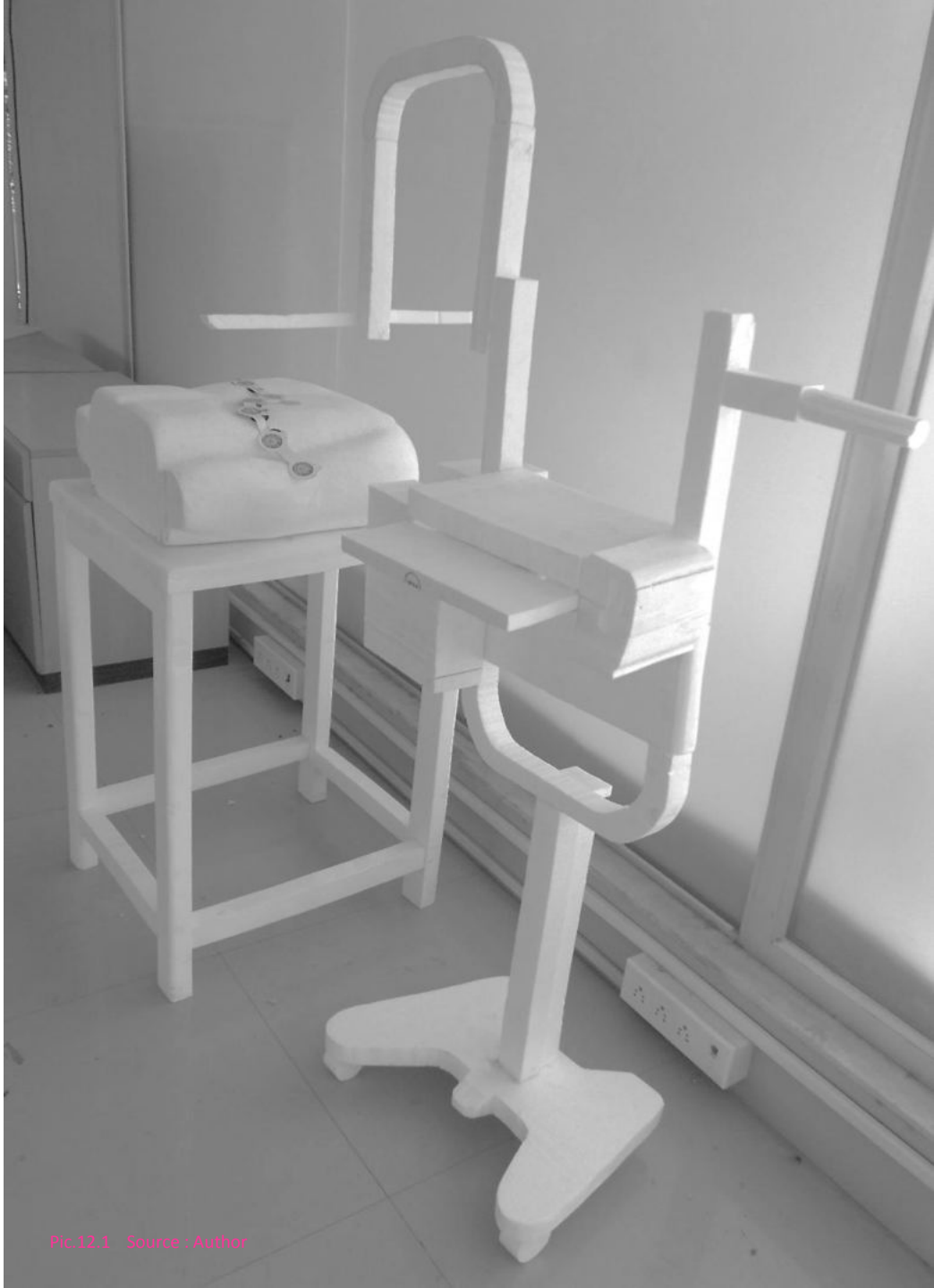
12 USER FEEDBACK

12.1 Mock up

A quick full scale quick mock up model of the concept was done and users from various fields , age and gender were asked to give their opinions regarding the concepts.

The process was kept open to understand their views from all the view points and aspects. The ECG technician from the Campus hospital was invited for his expert opinion. Even the concept was under scrutiny of the experts from medical and technical field.

The 3 concepts A, B and C were kept for display and get evaluated for the various criteria. The insights and the outcome of the feedback will be used for further development and refinement of the final concept.



Pic.12.1 Source : Author

12.1.1 User Observations

12.2 Expert Interviews

Mr. Batusadhu Kambale
Age group: 40-45
Experience: certified ECG technician
Background: Technical Radiologist IIT Bombay Hospital

Thoughts:

1. The concept of overhanging boom will be like an obstruction on the patient's view. Can't we eliminate it and have wires directly coming from the machine outlet?
2. The structure looks bulky . Can you reduce the size of the structure and make it more compact.
3. I liked the approach of using sticker for gel adhesion. It is innovative and looks promising.
4. The chest electrode gadget will simplify the process radically and entanglement of wire. It is really nice.
5. I am looking forward to have look at the final product.
6. The use of gas stay looks promising.

Dr. Trimbak
Age group: 25-30
Experience: Physiotherapist
Background: Senior Technical Assistant Betic Lab

Thoughts:

1. Please check the cost of manufacturing & the R & D cost .
2. The dustbin looks bulky. Please reduce the size of the dustbin and make it even more compact.
3. One can use small beads of the cotton in the cotton box.
4. There should be a balance in the looks of the structure by maintaining the proportions.
5. The boom looks like an obstruction. The process of using it needs to be validated.
6. Can we combine the trolley set up with the TMT (tread mill test)
7. The foldable bracket on the boom looks lengthy. Please shorten it down.

Tapas
Age group: 20-25
Experience: Electronics & Telecommunication
Background: Technical Assistant Betic Lab

Thoughts:

1. The boom looks like a hindrance and will be like disturbance for the patient and will be hectic to be used evrytime.If it was slid able it would have been an added advantage.
2. Can we provide L.C.D. display on the top for the ECG signals?
3. Can there be a provision for a lighting source on the structure?
4. Can we provide a self adjustable goose neck support for the boom.
5. Can the boom be a detachable or removable component?

Pic. : Author

12.2.1 Thinking in the expert's point of view

An interaction with the ECG Technician from the campus hospital & the Senior Technical assistants from Betic Lab helped in understanding various other issues which can actually affect the current concept.

The trial mock ups were user tested and the further intervention helped in figuring out what else can be improved and modified .

Overall there was a positive response for the wire management scheme in the concept and the development of the chest electrode gadget. However there was mixed response regarding the usability issues of the boom on the structure and the level of making the system more compact.

Pic. : Author

12.3 User Interviews

Mr. Rajan
Age group: 70-75
Experience: Material technology
Background: Workshop Supervisor

Thoughts:

1. Concept A looks good. I like the curviness of the structure.
2. Please check for the adhesive glue on the sticker. It can dry up. Understand the nature of glue that will be used on the sticker. They need to be stored in cool atmosphere.
3. Cardiologists do the ECG themselves. Look for their opinion.
4. People from medical field likes massive boom structured machines. I feel there is no need for the boom. It is an obstruction for the patient..
5. Peeling off of the sticker need to be taken care of. It should not pain while removal. Understand the sticking area and location points for tolerance & accurate reading.
6. Elliptical support for the ECG machine base will look good.
7. Base made up of cast iron will make it more stronger.
8. Provide internal wiring.

Vasundhara
Age group: 20-25
Experience: Animation
Background: M. Des. Student

Thoughts:

1. Concept C looks edgy & sharp. Concept B is more appropriate. Concept A reminds me of dining table.
2. Base of concept A is better. Can we merge it with the frame of Concept
3. Please look out for possibilities of addition of disinfectant solvent in the electro conductive gel.
4. I am worried about the sticker adhesion the skin. Kindly look into the matter & explore alternate possibilities.

Patric
Age group: 20-25
Experience: Product Design
Background: M.Des. Student

Thoughts:

1. Base of Concept A looks good& even the form is good for manufacturing.
2. Can the base be more stronger & bulked up & organic which can give it a strong look & there will be a balance of the structure.
3. The section of the boom looks big. Please check if we can it be reduced in size or a round pipe can be used.
4. Check for the center of gravity of the structure. Understand & calculate how much weight will be carried by the frame structure.
5. Increase the base size & make it wider.

Pic. : Author

12.3 User Interviews

Vipul
Age group: 25-30
Experience: Chemistry
Background: PhD Student

Thoughts:

1. Boom looks extra complicated. Can we remove it?
2. Interchange the location of the dustbin on the right hand size as it will be in vicinity of the patient and the smell of the ethanol chemical will be irritating.
3. Power chord should not be visible to the patient from behind. I t will look like chaos of wires. Kindly reduce the noise of maximum details in the machine.
4. Smaller wheels will be more helpful instead of big ones.
5. Provide an extra enclosure panel to cover up the wire organizer from behind..
6. The new electrode option looks quite innovative , but just check how well it sticks on the hand & remains stable on the limbs.

Paul
Age group: 25-30
Experience: Product Designer
Background: Research Assistant

Thoughts:

1. There need to be a check on the amount of the disposable waste .Will the sticker disposing actually helping the environment in terms of disposable waste control?
2. A debate needs to be brought into action to find out whether we are actually reducing the use of electro conductive gel in the other way round.
3. Kindly check for the optimal color scheme which can suit the environment of the hospital .
4. The concept of visually integrating the semantics of hand & chest electrodes for visual differentiation seems to be an innovative approach.

Boski
Age group: 20-25
Experience: Visual Communication
Background: M.Des. Student

Thoughts:

1. The issue of the sticker adhering on hairy chest will be a problem. It will be painful while peeling it off .
2. Visually concept A looks more expensive & concept C looks cheap.
3. Handle does not look like a handle. It should be semantically intervened to be understood as an intuitive component for grabbing and using. The section of the boom looks big. Please check if we can it be reduced in size or a round pipe can be used.
4. Is there a need for a handle? Cant we steer the system by just holding the structure frame?
5. Color of white with grey looks good.
6. Can you provide a screen for the ECG signal as an added accessory.
7. Patient also needs to know what is happening.

Pic. : Author

12.3 User Interviews

Chetan
Age group: 20-25
Experience: Mechanical Engineering
Background: Research Assistant

Thoughts:

1. Can we simplify the boom?
2. Just think of the whole structure & balancing of the structure.
3. Think about pushing and pulling while steering the equipment.
4. Can we keep the handle below the waist level.
5. Storage of the peripheral components needs to be worked out.

Amit
Age group: 20-25
Experience: Mechanical Engineering
Background: Research Assistant

Thoughts:

1. Increase the base size. Make it more broader.
2. The boom is hindrance. Please get rid of it.
3. Can we steer the whole structure by pushing it from the back side.
4. Think of a great color combination for the possible medical equipment look.

Pic. : Author

12.3.1 Thinking in the patient's psychological perspective

As I had conversation with the senior most employee of IDC, Mr. Rajan Govindarajan, I had different insights of the key issues addressed by the veteran.

He himself a patient and undergone the medical treatment explained the scenario of the concept and its direct effect on the patient's psychology.

Here are the brief excerpts from the conversation.

" When the patient enters the ECG room, he is already in tense situation. If he sees a big overhead boom coming over him., he wont understand what is going on. The gadget should not scary. In fact the process should look sophisticated to maintain the anxiety & blood pressure of the patient for better reading. Even if the wire management from behind panel is visible to him , he will get anxious.

Have you thought about the centralization of the patient on the bed? Will the boom every time travel towards the exact location over chest level?

Have you looked into the process how the medical staff shaves the chest before ECG reading? Its painstaking & will be more hectic with the sticker peeling off."

Pic. : Author

12.4 Concept Evaluation

The concepts are evaluated on a system that distributes 1 point to all the concepts in each parameter

Parameters	Concept A	Concept B	Concept C
Appearence	0.3	0.5	0.2
Comfort	0.3	0.3	0.2
Compactness	0.2	0.4	0.3
Ease of operation	0.3	0.4	0.3
Visual Balance	0.3	0.4	0.2

Concept B wins with integrating some aspects & features from Concept A

THINKING .....

12.5 Further Scope of the project

The further scope of the project involves the refinement of the existing concept with the inputs gained from the user feedback and personal intervention. The major challenge is to integrate the product with the existing environment.

Following aspects of Industrial Design can be touched during the final refinement.

- **Value Addition**
- **Developing a Business Model**
- **Branding**
- **Positioning in the medical Market segment**
- **Material specification , detailing and manufacturing cost**
- **Packaging**

Pic. : Author

13

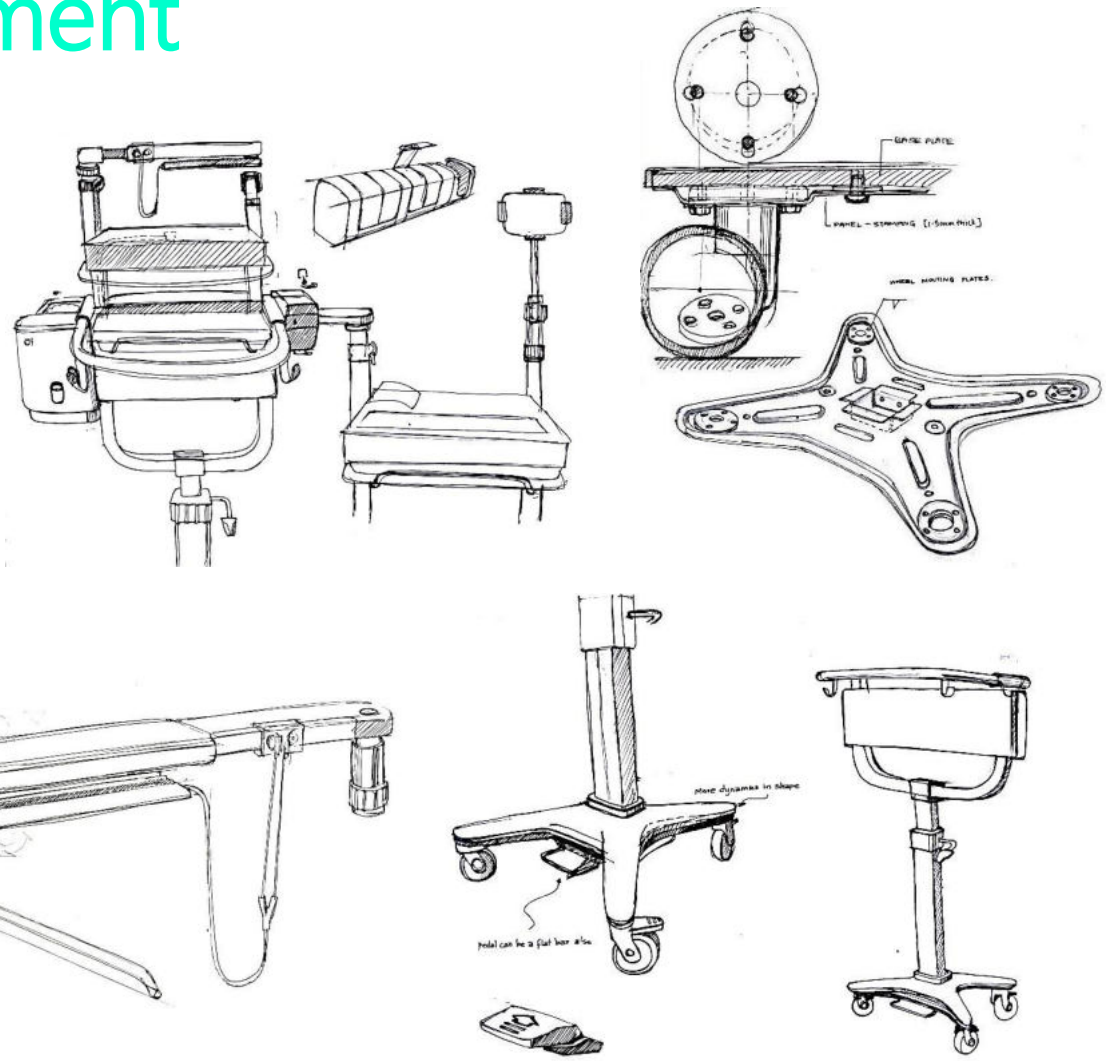
FURTHER REFINEMENT & BRANDING

13.1 Further Refinement & changes

The valuable inputs from different users were helpful in bringing out many shortcomings in the design & these inputs were used for refinement & major changes in the trolley system design.

The boom was simplified to a minimalistic pivotal stick. The base profile and spread was increased for further strengthening of the structure thereby providing the balance. A LCD display mounting bracket was introduced.

Storage space for the electrodes was worked out. The slid able handle was integrated with storage space for the flexible disposable electrode kit plus maneuverability. A simple glass base was provided for the ECG machine placement giving it a clean and clinical medical equipment look.

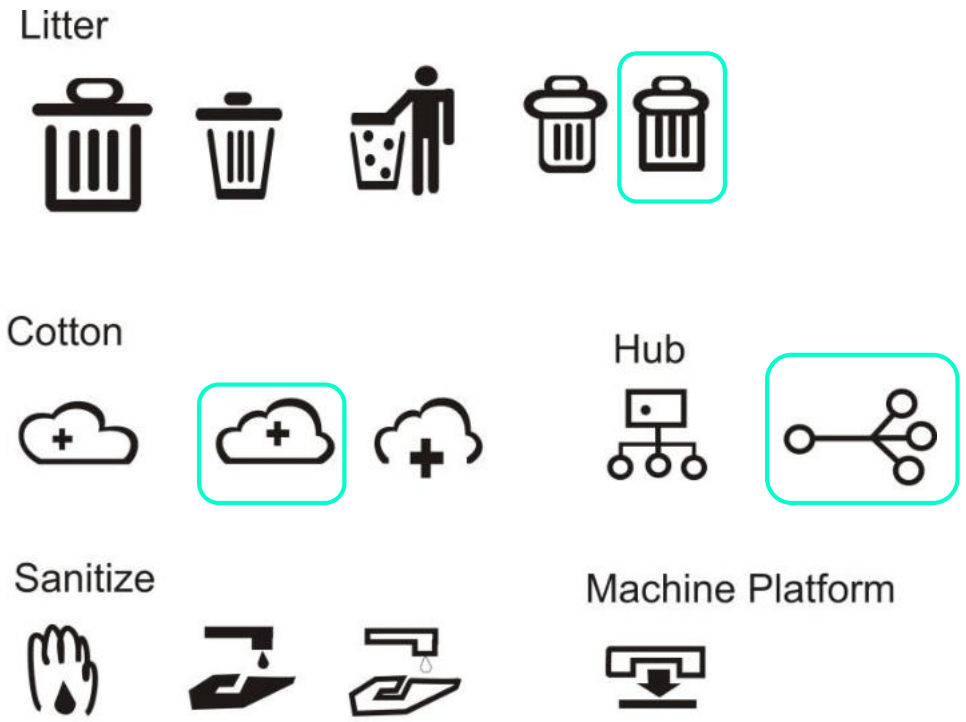


13.2 Icon Design

The next step included in the project was to design and develop icons for visual interaction between the user and the product. These icons can be placed on the various components of the system and will direct the user to understand and follow a streamlined activity to be performed during the recording process.

The main objectives full filled with the icon representation will be to

- **Make the process visually interactive**
- **Make the activity self intuitive thereby providing ease of use to semi skilled user**
- **Minimalistic instruction detail**
- **Easily understandable process**

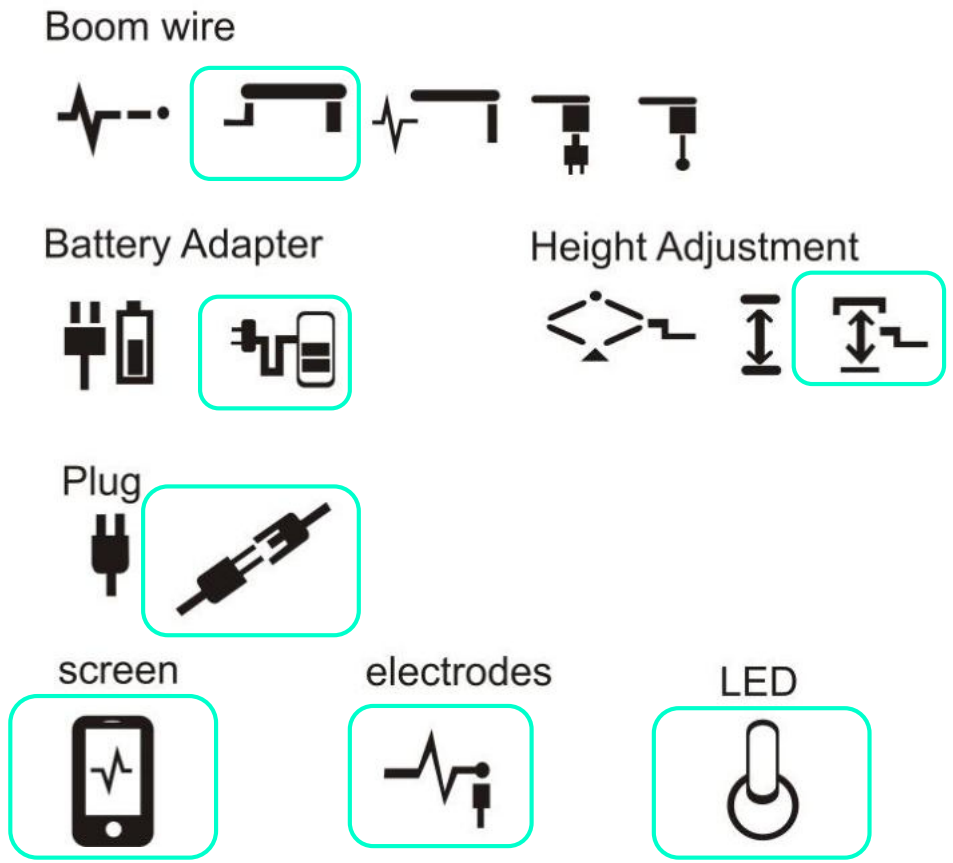


13.2 Icon Design

The icons were illustrated and then selected after some deeper thinking. These icons needs to be placed to make them visually communicative.

These icons can be either screen printed on the surface or they can be pasted as transparent stickers.

The next step in the exploration will be optimize and freeze the exact possible location in the further study.



13.3 Branding

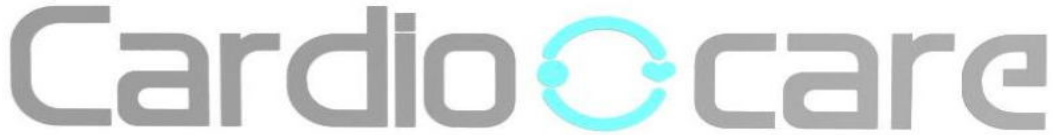
The branding of the product involves consideration of series of explorations of various aspects to actually convey the expression of the product. The initial imagery started with the sketches of an ecg technician taking care of the heart.
Meanwhile the heart was depicted as the generic heart symbol which is much familiar to the eye. This can bring in the relation of the heart and the medical field together.

The font was developed to accommodate the symbol within itself. The color scheme was kept simple with the greyish color for the letters & turquoise for the symbol.

The name symbolizes the care taken during the process of ECG recording & the font is developed considering the minimum radii generated in the structural members of the developed ECG system.

Series of explorations

Selected Logo



14 FINAL CONCEPT

14.1 First Look

MEET
Cardio care

WITH YOU AT EVERY STEP

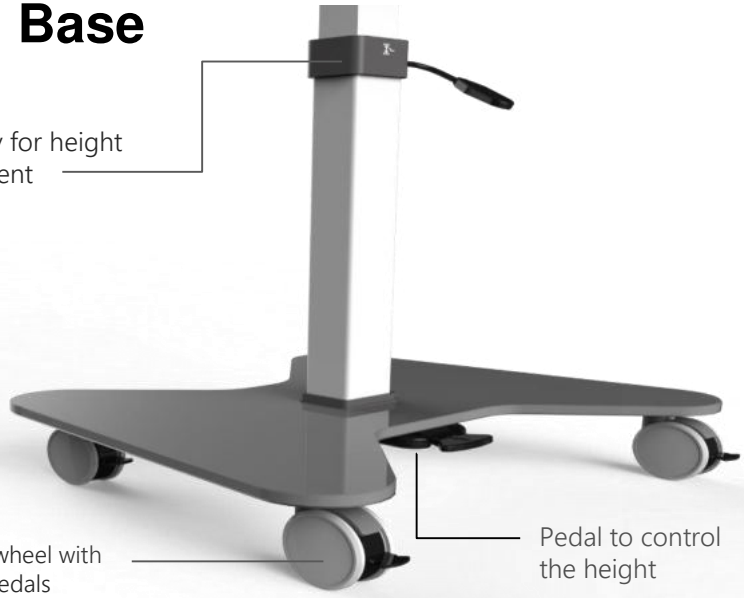
Finally, A system that could actually make the life simpler

With the CARDIO CARE system, you can:

- Enhance ECG Recording Experience.
- Streamline your routine workflow.
- Improve the communication with the patient.
- Increase portability.

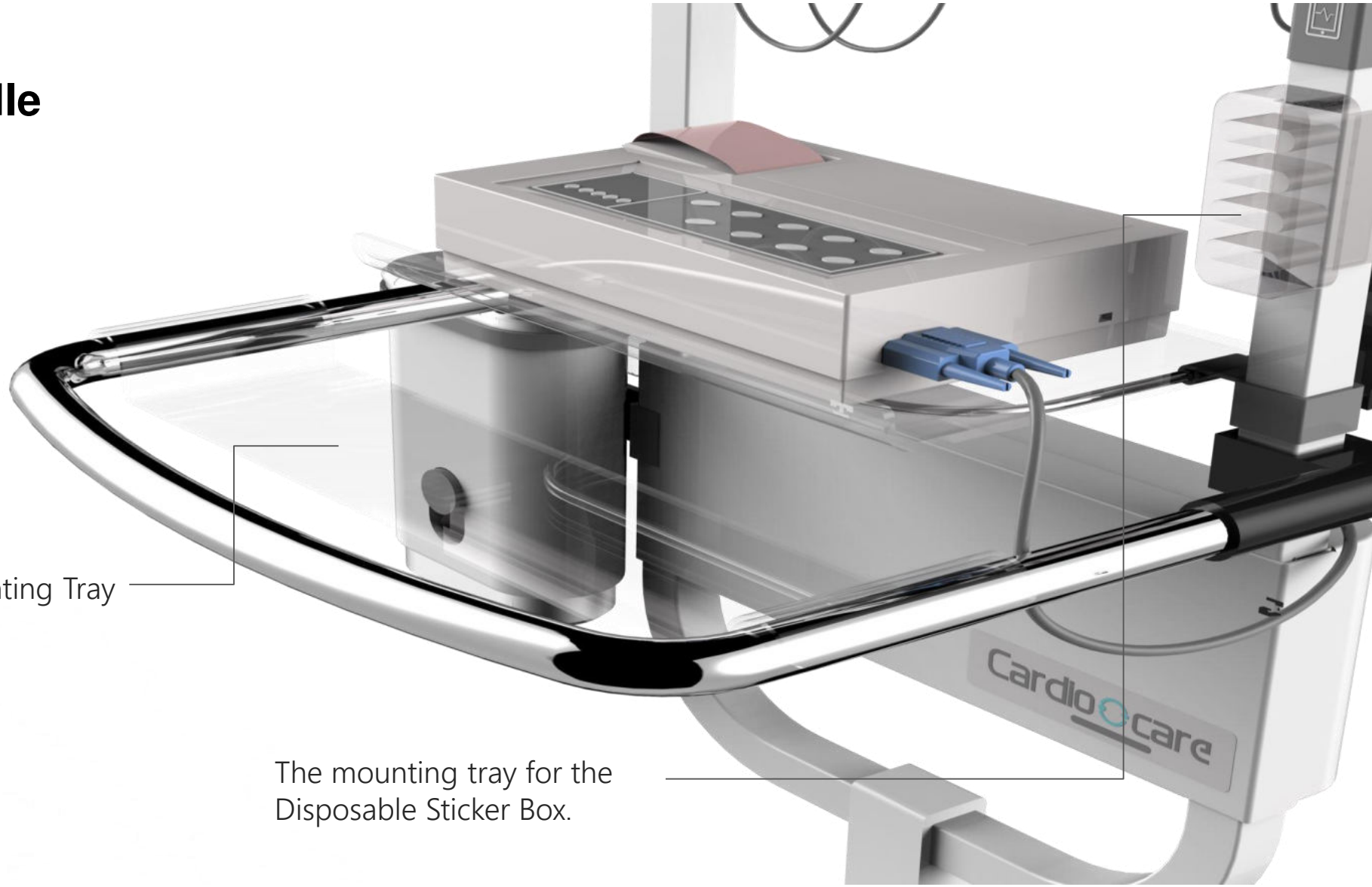

Cardio care
WITH YOU AT EVERY STEP
Cardio care

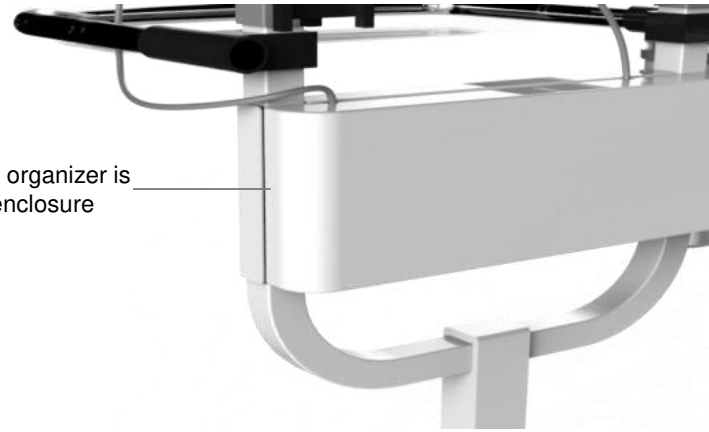
Base



Utility Box

Handle


The Mounting Tray
The mounting tray for the
Disposable Sticker Box.
Cardio Care



The Back wire organizer is closed by an enclosure

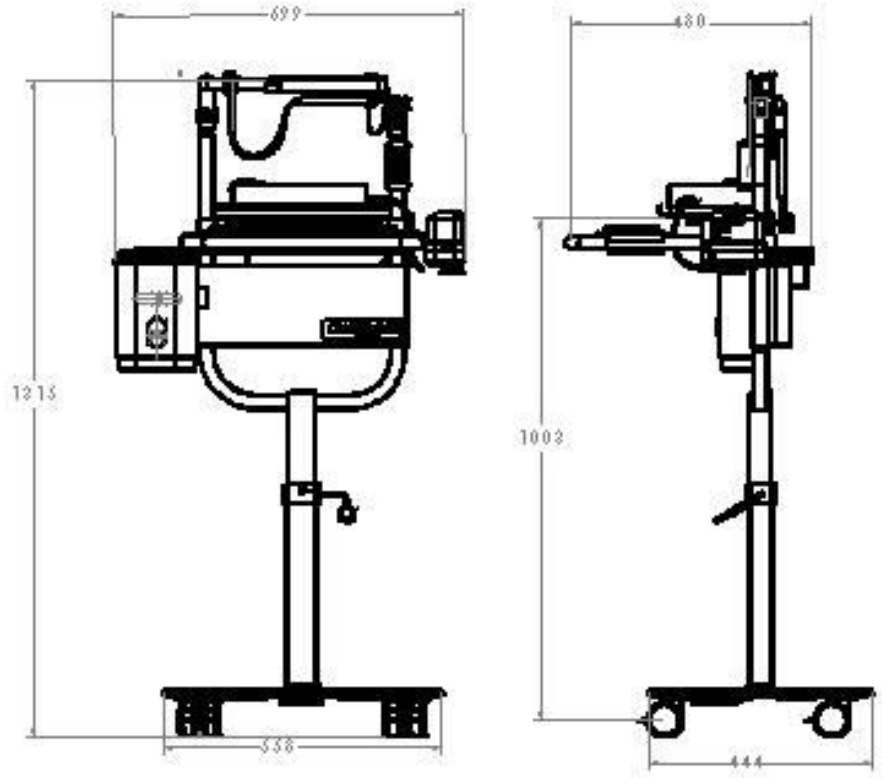
Bracket for Mounting LCD Display

Glass Base For ECG machine

14.2 Value Proposition

- Organized workflow
- Organized wire management.
- Ergonomically designed workspace.
- Minimal Lean structure.
- Minimal elegant looks.
- Use of Antibacterial materials with high finish.
- Controlled use of gel & less cumbersome process.
- Efficient accessory management.

14.3 Dimensional Details

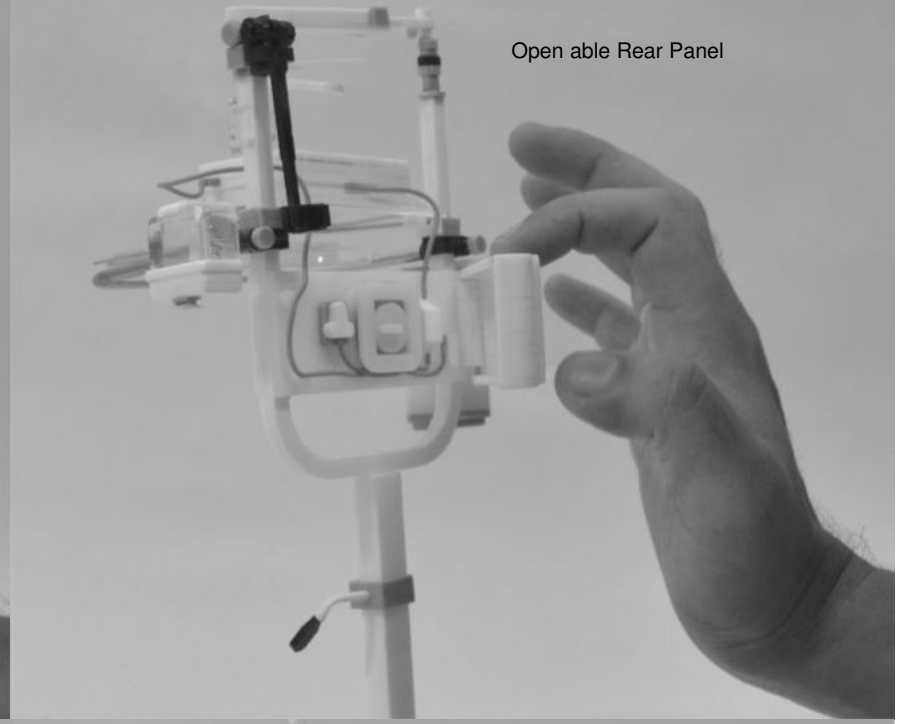


14.3.1 Mock Up - Scaled down model

Scale of 1:5

Front View

Rear View


Open able Rear Panel


Detachable Utility Box

14.4 Conclusion

The project started becoming interesting during the concluding phase as we started going deeper in understanding the user centric aspects of the concept & then further validation with user feedback and expert opinions. The project helped me in invigorating my thinking at system level and understand the pros and cons of how to effectively manage and build a concept right from scratch to a product which can be mass produced & product which can make a big difference in the existing ECG recording scenario.

The next big step will be to work & develop a concrete interaction between the product and the user. The whole system can be developed as a business model considering the mode of manufacturing , material specification and engineering design. The project also needs to be revisited considering & analyzing the current medical market segment & how to position it accordingly.

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The people with whom I interacted

Mr. Shreyans Gandhi, Co Founder YOLOHealth Services, Mumbai

Mr. A . Agarwal, Co founder Uber Diagnostics, Cardiotrack, Bengaluru.

Dr. Deepika Chari , Junior Resident, Anasthaesia Department, Goa Medical College , interview by Author

Dr. Manjunath Dessai, Senior Consultant Cardiologist , Goa Medical College , interview by Author

Mr. Tushar Rane, Mrs. Vinda Joshi (Casualty Ward) **Mr. Fideles Fernandes**, (OPD Ward) Senior ECG Technicians. Goa Medical College , interview by Author

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