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# Improving Sentinel Node Gamma Imaging Workflow with Lean Methodology

– A Development Project at the Helsinki University Central Hospital,  
Medical Imaging Center, Department of Nuclear Medicine

Metropolia University of Applied Sciences

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<p><b>Background</b> One in eight women gets a breast cancer at some point of their lives. In 2012 there were 4 694 new breast cancer cases in Finland. The surgery is as breast conserving as possible. To find whether cancer has spread to sentinel nodes, sentinel node gamma imaging is performed. Axillary evacuation is only performed if cancer is found in sentinel nodes. (Joensuu, Heikki 2007: Syöpätaudit. Section 32 Rintasyöpä)</p> <p><b>Aim and Purpose</b> The aim of this development project was to standardize practices, increase patient safety and increase efficiency. The purpose of the project is to guarantee more equal service for all the patients having sentinel node gamma imaging, independent on the performing technician.</p> <p><b>Methods and Process</b> Because of the high incidence of the breast cancer, sentinel node gamma imaging is the second common study in the Nuclear Medicine Department. For workflow improvement needs Lean methodology was selected. The Lean team was multi professional consisting of doctors, a physicist, laboratory technicians, and a radiographer. Tools used to analyze workflow were VSM, spaghetti diagram, 5S and throughput time following. The project lasted from January to June 2014, and the first changes were implemented already during spring.</p> <p><b>Results</b> Lean team implemented 11 changes, which was more than expected. The project produced for example four new guides, more free camera time, reduced injection doses and a visual confirmation about injection spot. However the greatest success was that continuous improvement holds strong even after the project was finished, meaning that Lean culture has adopted in Nuclear Medicine Department.</p>	
Keywords	Sentinel node, Gamma imaging, Lean methodology, Lean culture, Nuclear Medicine

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## List of Used Concepts

Medical Imaging – in this context includes Radiology and Nuclear Medicine procedures

Technician – Includes both radiographers and biomedical laboratory technologists, because both are working in Department of Nuclear Medicine, and there is no need to identify/separate employees by occupation.

MBq – Mega Becquerel, radiation activity unit (International system of Units)

Tracer – is a radioactive isotope injection, given to peripheral vein or intra cutan

$^{99m}\text{Tc}$  – The Metastable Nuclear isomer of Technetium 99, the most common radioisotope

Sentinel node – A lymph node that is the first line through which cancer spreads

Axilla – the armpit area below shoulder joint

Probe – handheld device to find radioactive sentinel nodes

MISPI3 – Philips Gamma Camera where sentinel node examinations are performed

Quarter – in this study refers to the quarters of the breast

Seed – radioactive seed which is inserted close to a tumor for easier localizing

Tumor – a mass inside the breast

## 1 Introduction

Nuclear medicine has been used in healthcare since the 1920's. They are used to study functional diseases in organs and body metabolism as opposed to general X-rays and MR, which concentrate more to study structures and anatomy. Radio nuclides used in healthcare are artificially produced. In Finland there are 16 different nuclides in use. As many as 84 % of studies are performed with  $^{99m}\text{Tc}$ , technetium-99m. Other common nuclides are  $^{123}\text{I}$ , Iodine-123,  $^{131}\text{I}$ , Iodine-131 and  $^{111}\text{In}$ , Indium-111 and  $^{18}\text{F}$ , Fluoride-18.

Radio nuclides are often given to patient through i.v cannula, into a peripheral vein. In sentinel imaging however radio nuclides are injected inside the skin, using intradermal injection. With gamma camera radionuclide can be followed how it spreads or exits from organ, this type of exam is called dynamic study. Static images show how nuclide accumulates on different timepoints. These images can be repeated on different times p.i, post injection and using multiple camera angulations. (Korpela, Helinä 2004: Isotooppiilääketiede, Säteilyturvakeskus.)

Nuclear departments in Finland perform a total of nearly 37 000 gamma imaging studies a year. Sentinel node examinations are the 3<sup>rd</sup> most common study with over 4200 yearly examinations. Only the whole body bone scanning with nearly 11500 studies and myocardial perfusion exam with 4500 yearly studies are more common. (Finnish society of nuclear medicine, Tuiketiedote 2/2013, 19.12.2013 page 4.)

Sentinel gamma imaging relates tightly with breast cancer, which is the most common cancer in women. One in eight women gets breast cancer at some point of their life, and around 4 500 new cancer cases occur every year in Finland. It is also the leader in the statistics of cancer deaths in Finland. According to the survival rates of cancers diagnosed between 2002-2009, 97 % of patients were alive after one year and 89% after 5 years. (Finnish Cancer Registry. Cancer in Finland 2008 and 2009. Publication No. 84.)

HUCH Medical Imaging Center, Department of Nuclear Medicine, delivers a large variety of gamma imaging services, as well as PET/CT scanning and iodine and phosphorus treatments. The PET/CT scan is the most common examination with nearly

1500 examinations per year. Second largest group is sentinel node gamma imaging with 1100 yearly examinations. (Meilahti Qpati statistics 2012.)

The aim of this development project was to standardize the methods and workflow used in sentinel node gamma imaging. Purpose of project is to guarantee more equal service for all patients having sentinel node gamma imaging, independent on performing technician.

## 2 Breast Cancer

Breast cancer is the most common cancer type among Finnish women. Every year more than 4000 women are diagnosed with breast cancer, meaning roughly every eight female in Finland. In 2012, 4 694 women were diagnosed with breast cancer in Finland (Joensuu, Heikki 2007: Syöpätaudit. Section 32. Rintasyöpä) and in 2009 out of 4 461 cases 821 cases were fatal. Mortality rate between years 2005-2009 in Finland was 14,2. Each year also a few males get breast cancer. In 2009 there were 16 new male breast cancer cases, three of them fatal. Survival rates are quite high and 97% of breast cancer patients are still alive after 1 year and 89 % after 5 years. (Finnish Cancer Registry. Publication No. 84). Increasing incidence is mainly because of women's higher age. Breast cancer is relatively rare among under 30 year-old women, but it becomes more frequent among women 45 years and above. (Joensuu 2007.)

There are several known risk factors that affect breast cancer incidence: just to name a few; obesity, ionic radiation, alcohol, childlessness, early starting age of periods and late starting age of menopause. There are genes like BRCA1 and BRCA2 that are linked into hereditary breast cancer. Those types are estimated to cover 5-10% of all breast cancer cases. Factors decreasing probability of breast cancer are athletics, giving birth at early age, multiple pregnancies and surgical removing of breasts. (Joensuu 2007.)

National screening program invites all women between 50-69 years to free screening every two years. Mammography screening is a basic study to examine breasts. To diagnose breast cancers in Finland there is a so called triple examination, including palpation, mammography (+ ultrasound) and core biopsy. (Joensuu 2007.)

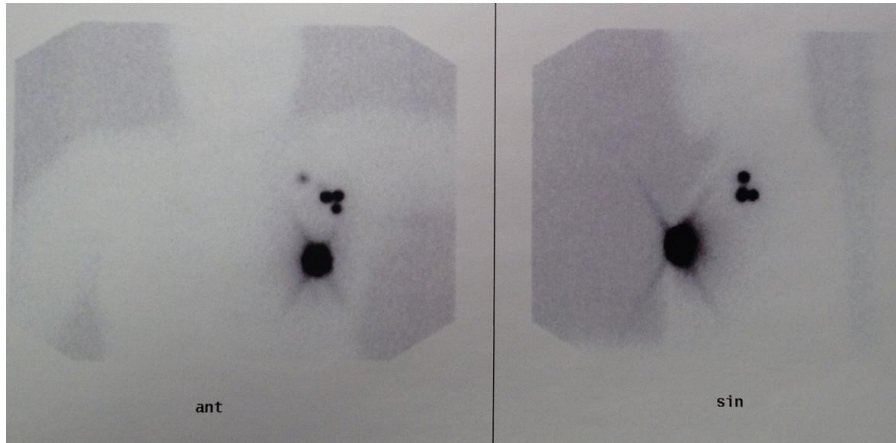
Malignant tumor is surgically removed, and the surgery is always as breast conserving as possible. In the order to find whether cancer has spread to sentinel nodes, sentinel node gamma imaging is performed. Axillary evacuation is only performed if cancer is found in sentinel nodes. (Joensuu 2007.)

## 2.1 Sentinel Node Gamma Imaging

Publications and researches shows that breast cancer spreads through lymphatic drainage and through blood vessels. Therefore first metastases are likely to be seen on the first lymph node cancer cells meet. These first line lymph nodes are called sentinel lymph nodes. It is common to find more than one sentinel lymph node in a patient. It is important to identify the sentinel nodes because this affects treatment options. If metastases are not found in sentinel nodes patient is more likely to avoid larger surgical operations. (Leppänen – Ahonen, 2003: Vartijaimusolmukkeen gammakuvaus, Kliininen fysiologia ja isotooppilääketiede p. 599)

Radioactive tracer is injected either into the primary tumor or close to it at HUCH Imaging Center, Department of Nuclear Medicine. The tracer dose is normally 37-120MBq  $^{99m}\text{Tc}$  in 0,15-0,2 ml volume. The tracer is followed by gamma camera after 0,1 – 5 hours. Sentinel nodes are pictured in anterior-posterior and lateral angulations (Picture1) and sentinel nodes are marked on the skin with a permanent marker. The operating surgeon will find active sentinel nodes with gamma probe and removes them. (Leppänen – Ahonen, 2003 p. 599.) Tracer can be found with a probe even after 24 hour post injection. The surgeon may additionally use Patent Blue – blue color injection during operation, to facilitate finding the sentinel nodes. If this is used, surgeon removes all blue colored nodes and active nodes as well. Removed sentinel nodes delivered to pathologist for further examination and, if metastases are found lymph nodes are evacuated extensively from the axilla during the same operation. (Jahkola – Virolainen– Leppänen – Suominen 2002: Ihomelanooman vartijaimusolmukebiopsia.)





Picture 1. Sentinel nodes in the left axilla      Picture: Henna Lähdeniemi

### 3 Quality Management in Healthcare

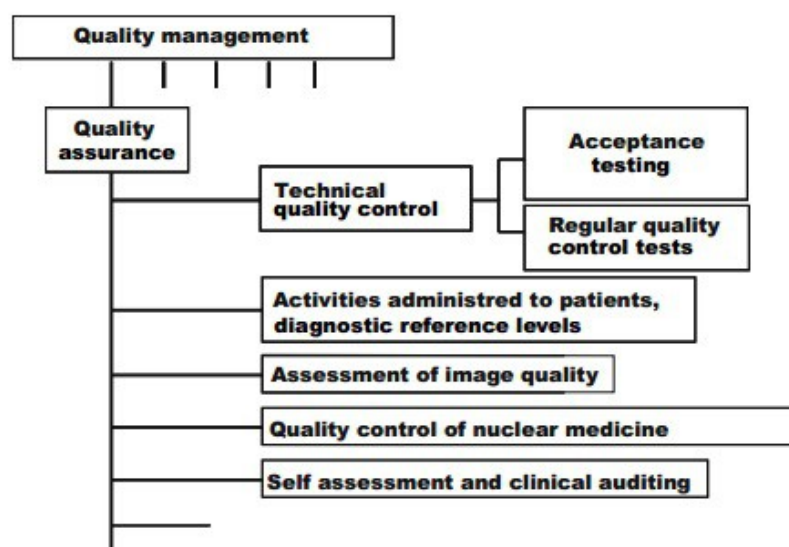
Quality management is a term that describes all activities ensuring product or service consistency. In hospitals, quality improvement and management have multiple layers. Technical quality (equipment quality) in healthcare is assured with Quality Assurance programs. Processes secure patient and employee safety and procedures quality management are for employee performance. All this aims at total quality improvement to deliver better care for patients. In radiology, main development is improving processes and procedures on selected services delivering better quality, more safely and more effectively. (Kruskal – Eisenberg – Sosna – Yam – Kruskal – Boiselle 2010: Quality improvement in Radiology.)

#### 3.1 Quality Management in Medical Imaging

Quality management in the healthcare sector is a combination of multiple factors. Quality improvement is based on quality assurance programs, process management to increase safety and procedures improving overall performance. Purpose is to build up a working culture where individuals are confident to point out failures and flaws in system. Humans make mistakes, and the courage to disclose errors is important. There should not be a fear of punishment. To help identify problems, culture should be more proactive on monitoring, instead of reacting afterwards when problems have occurred. A key to successful quality management is human resources: engaged staff and high quality team to constantly work towards safety and quality goals. Sharing best

practices and employee trainings are important initiatives for quality management. (Kruskal et al. 2010.)

Quality assurance is only one part of quality management and technical quality assurance belongs into it. Technical quality assurance can be divided into purchase inspection and regular tests that are performed weekly/monthly/yearly. Other part of quality management include patient dose monitoring and comparison levels, image quality, Repeat-reject analyses, self-assessments, functionality assurance and clinical audits. (STUK ST 6.3.)

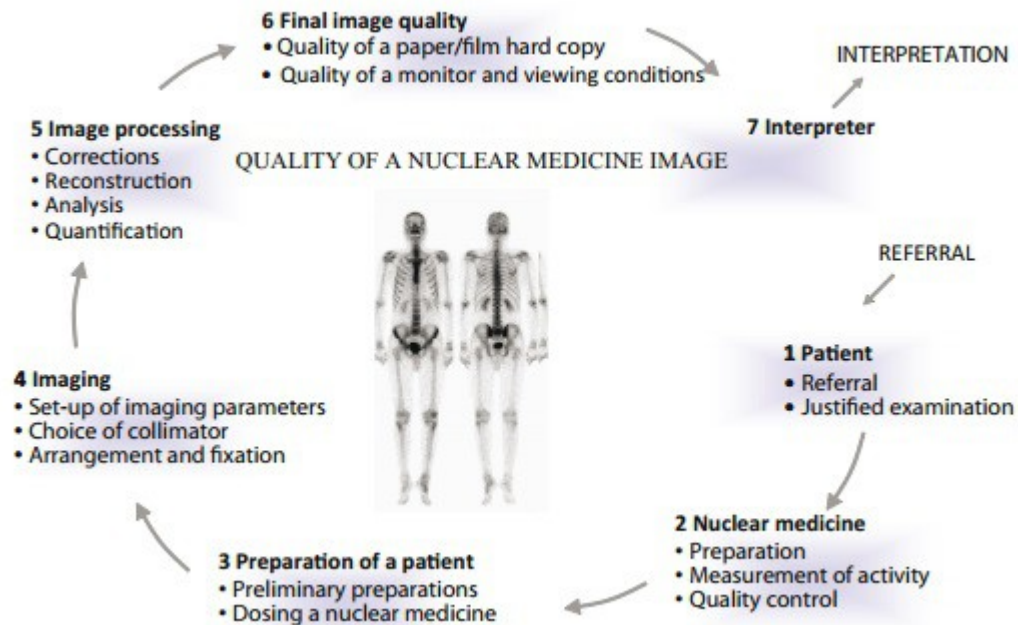


Picture 2. Advice from STUK 1/2010, Quality Control Guidance for Nuclear Medicine Equipment (Copy rights STUK, permission of use accepted 7.10.14)

STUK - Radiation Nuclear Safety Authority has published several recommendations and regulatory guidelines on the use of radiation, including the ST guides. ST 6.3 and STM 423/2000 concern gamma imaging and nuclear examinations. New gamma cameras have to be CE marked, to satisfy EU requirements. After installation it is mandatory to perform purchase inspection to ensure that the equipment is safe to use. During life cycle of equipment it is mandatory to perform functionality and quality assurance tests regularly. Functionality tests include mechanical testing, emergency stop tests, radiation protection tests and radiation alarm tests. Quality assurance tests are weekly or monthly performed tests, measuring image quality, linearity, uniformity and radiation doses. Values should stay inside set boundaries. Quality assurance

guides and results have to be in written format and include specific information about tests, equipment, frequency of tests, acceptable variation and instructions in case results do not meet boundaries. (STUK ST 6.3.)

Image quality is a sum of multiple factors. In quality assurance the aim is to standardize all these factors.



Picture 3. Advice from STUK 1/2010, Quality control guidance for nuclear medicine equipment (copy rights STUK, permission of use accepted 7.10.14)

Patient dose optimization is not only technical quality assurance, but more continuous development of examination procedures. The technical quality assurance of equipment means all lifecycle time tests and monitoring to ensure that clinical benefits are received and the patients are not subjected to higher doses than what reliable diagnoses require. Since images have been transformed from films to a digital archive, viewing images has changed. This requires making viewing conditions stable and optimizing image processing and imaging protocols. Clinical training ensure safe usage of new systems when new system is installed. It is also important to educate new employees or when lots of users are changed. (STUK ST 6.3.)

The ALARA (as low as reasonably achievable) rule means having good enough image quality with lowest dose possible while maintaining diagnostic quality. There are reference doses for x-ray examinations as well isotope examinations set by STUK. In sentinel node gamma imaging, the dose is directly comparable to injected radiation dose. However there are no reference doses set by STUK. (STUK ST 6.3) EANM recommendations are to use doses between 5-20 MBq in a maximum 0.2ml volume, depending on the time between injection to surgery. Air bubble should be used to push the tracer out of the syringe. Images can be captured from 1,5 hours to 4 hours (even 18 hours) after. (EANM Guidelines 2007: Sentinel node in breast cancer procedural guidelines.)

### 3.2 Quality Management Systems

Different quality control / quality management systems all aim at more or less the same results. In healthcare this means less variation in processes and better quality of care. Past years and studies have shown that the healthcare sector can adapt industrial techniques in quality management. (Komashie – Mousavi – Gore 2007: Quality management in healthcare and industry: A comparative review and emerging themes.) In healthcare organizations, the improvement focus is on clinical outcomes, patient satisfaction and efficiency in care delivery. There are six attributes that stands for quality:

- Safety
- Effectiveness
- Patient-centered
- Timeliness
- Efficiency
- Equitable

(Taner – Sezen – Anthony 2007: An Overview of Six Sigma Applications in Healthcare Industry.)

#### TQM

Total quality management has a holistic view and a people-oriented scope. TQM can't be successful without employee commitment. TQM offers tools and principles to aim for continuous improvement, but needs cultural change to support change. TQM

implementation can start by using the 4P model, which emphasizes People, Partners, Processes and Products. Organizational excellence starts from leaders with proper training and needed competencies followed by similarly trained and talented employees.

The ILL index (Innovativeness, Learning and Lean) was originally developed in healthcare, not in the manufacturing industry, but it has been implemented in other industries as well. The ILL describes the level of excellence with values between 0 and 1.0. ILL index 1.0 means an ideal case and lower score show percentage need for improvement. A low index score means organization is far away from excellence (ILL). (Daahlgard – Pettersen – Dahlgaard-Park 2011: Quality and lean in healthcare: A system for assessing and improving the health of healthcare organizations.)

### SIX SIGMA

Six sigma is a business strategy that aims to deliver nearly perfect service. As the name hints, Greek letter Sigma denotes variability or standard deviation. This ideology stands for reducing variation and focuses on delivery of care, administrative support and financial outcome. It gives measurable tools to measure performance and relies on statistical analyses. The starting point for six sigma management comes from customer requirements and customer value. There are sigma levels highlighting healthcare performance. The higher the value the better the performance. To implement six sigma cultural changes to get even higher sigma level, DMAIC has to be followed. Starting a six sigma process requires investment in six-sigma Belt System training. Six sigma statistics give a lot of information. (Taner et al. 2007.)

DMAIC is an acronym of the words Define, Measure, Analyze, Improve and Control. It is another tool to start systematic change and improvement based on having measurable objectives and goals. The process starts with measuring a workflow and analyzing the gathered data. Alternative solutions may be tested and outcomes measured. After implementation of best solution monitoring must be applied to see if the results are permanent. This tool often includes use of VSM, value stream mapping. (Aakre – Valley – O'Connor 2010: Improving Patient Flow for a Bone Densitometry Practice.) DMAIC works as a cycle and aims at the continuous reducing of errors/ mistakes.

DMAIC implementation should follow DFSS (design for six sigma) cultural change. But these can also be applied in a different order, using DMAIC to analyze the current state and start changes with the DFSS. Six sigma has 7 core concepts:

- Critical to quality
- Defect
- Process capability
- Variation
- Stable operations
- DFSS
- Lean six sigma ( integration with lean concepts)

(Taner et al.2007.)

#### BENCHMARKING

Benchmarking is a tool to improve service quality using existing knowledge. The idea is to compare best practices between other companies that are more successful in the area where improvement is needed. It is important to define clearly what the area to be benchmarked is and to create a list of compared things or asked questions. The result is implementing best practices and learning more about the reasons why someone else did a better job. (Ojasalo – Moilanen – Ritalahti 2014 : Kehittämistyön menetelmät.)

## 4 Lean

Lean is not just a management tool, or a quality system, it is much more. Exact definition of Lean may not exist, but it can be seen for example as a way of working, culture, production system, strategy or a mindset. Adaption of Lean methodology needs deeper understanding of own work. Since Lean was invented in car industry, it may not be directly copied to all other businesses. Lean should not become a goal itself, it should just help to reach the set goals. As Modig and Åhlström state in “This is Lean,” standardization should not be the goal, but a tool in achieving something (like patient safety). It is important to understand the difference in means and goals. (Modig – Åhlström 2013: This is Lean p.90.)

One definition of Lean is as follows:

Lean Healthcare is a management philosophy to develop a hospital culture characterized by increased patient and other stakeholder satisfaction through continuous improvements, in which all employees (managers, physicians, nurses, laboratory people, technicians, office people etc.) actively participate in identifying and reducing non-value adding activities (waste). (Daahlgard – Pettersen – Dahlgard-Park 2011: Quality and lean in healthcare: A system for assessing and improving the health of healthcare organizations p.677).

For this development project I chose to use Lean methodology, because it is used widely in healthcare sector. Lean projects have also been implemented in Medical Imaging context and there were plenty of reference studies available. But more importantly results achieved with Lean methodology are impressive and it engages employees. People in real working environment are in key role to start Lean implementation.

#### 4.1 Lean Principles

“Lean is the term used to describe a principle based continuous quality improvement” (Clark– Silvester – Knowles 2013: Lean management systems: creating a culture of continuous quality improvement). The Lean concept derives from Japan and the Toyota Motor company factory. Lean term was invented in the 1990’s. At that time it came clear that manufacturing problems are universal and the Toyota model could be applied in other industries and in non-Japanese companies as well. The Basic idea is value creation through waste elimination. (Teich – Faddoul 2013: Lean Management, The Journey from Toyota to Healthcare.) Surprisingly, as much as 35% of daily work was discovered to be waste at Toyota Production System. (Jimmerson – Weber – Sobek 2005: Reducing waste and Errors, piloting Lean Principles at Intermountain Healthcare). Lean has four key principles to make it work: teamwork, communication, continuous improvement and efficient use of resources and elimination of waste. (Modig – Åhlström 2013 p.77.)

Lean methodology concentrates on processes which are present in everyday activities and ease the flow inside them. It is important to analyze processes according to a “flow unit”, which refers to the thing that moves inside the process. In healthcare this can be goods, information or patient, for example. Mistakes are often made in seeing process from the organization’s point of view, instead of the flow unit’s perspective. This flow efficiency differ from resource efficiency in the same way; instead of concentrating on value adding time by resource Lean flow efficiency highlights value receiving time per



time period. Throughput time is a measurement used to see how long one process takes. (Modig – Åhlström 2013 p.17-25)

Five basic Lean principles are

- 1) Identification of customer value (defined by customer)
- 2) Management of “value stream”
- 3) Developing capabilities of flow production
- 4) Use of “pull” mechanism to support flow of materials
- 5) Pursuit of perfection through reducing forms of waste to zero

(Clark et al. 2013.)

The identification of customer value starts from the premise that a product or service is something that customers want and are willing to pay for. Identifying value stream and focusing on having only value adding steps in process are key elements. If non-value adding steps exists, the organization must to get rid of them or change them into value adding steps. Once steps are defined it is important to ease the flow on each step to help product flowing towards customer. Trying to avoid bad inventory which customer does not want Toyota firstly introduced build-to-order production. Zero inventory and building cars according to orders created a “pull mechanism” to support the workflow. According to Toyota there are seven kinds of waste (muda) to avoid to optimize workflow:

- Waiting
- Unnecessary transportation
- Inventory
- Motion
- Defects / Errors
- Over-processing
- Overproduction

(Modig – Åhlström 2013 p.78.)

An eight waste is often mentioned and it stands for human potential. This may be unused talent, lack of commitment or burned out employees. The Japanese word muda is this general waste. In addition to that there is the muri waste meaning



overwork/overburden and the mura for uneven workload. (Graban, Mark 2008: Lean Hospitals p.3-4,8,38.)

Since Toyota times Lean management has aimed to do right things on right time. If problems occur process is put on hold, and mistakes are corrected so that faulty parts or errors do not meet the customer. Quality management has to occur in each step of the workflow. (Modig – Åhlström 2013 p.78.)

#### 4.2 Lean in Healthcare

Introducing Lean to healthcare is not a new thing. Lean methods (without calling it Lean) have been used from the 1920's. Lean has spread in healthcare because hospitals should aim for efficiency (cash flow), customer satisfaction and quality. Lean highlights respect for people, for employees and customers. (Graban 2008 p.3-4, 23.) Lean is suited for health care also because the main concept is seeing the service from the customers point of view and understanding value creation as defined by customer. It guides directly to change and towards improvement helping to gain safety, quality, efficiency and appropriateness. In Healthcare, better quality of care does not mean more costs, it is the opposite. (Kim – Spahlinger – Kin – Billi, 2006: Lean Health Care: What Can Hospitals Learn from a World-Class Automaker?.) Actual Lean development projects have existed in healthcare since the 1990's and there are places where Lean has increased quality, and access while decreasing costs. (Graban 2008 p.3-4, 8.)

Healthcare organizations using Lean management have proven to decrease the amount of errors, shortened queuing times and increased productivity. The aim of Lean is to make things and work more efficient and smart, not to make employees work more and harder, only wiser. The Lean method takes whole process into account end-to-end and tries to find waste and problems inside processes. The total goal is to standardize processes. Each piece inside a process has a certain content, sequence, timing and outcome. The most common way to apply Lean philosophy to healthcare is to use it in an independent service or workflow. (Clark et al 2013.)

Lean implementation in healthcare requires a patient centered focus, time and playing performance measures / value metrics. Customer needs and requirements are define value and waste constitutes. Waste can be activities such as overproduction, large

inventory on stock, poor design of working area or transportation. (Teich – Faddoul 2013.)

Waste can be described as something that needs resources, but does not increase value to customer (patient). In Lean management, the other element beside process improvement are worker commitment and cultural change for continuous improvement. (Clark et al 2013.) Successful Lean implementation requires a clear view of what purpose Lean serves, how it suits to organization-wide planning and how it could be applied to intra-organizational projects. Answering these questions helps to relate Lean into an organization strategy. (Daahlgard et al 2011.)

The amount of waste in healthcare is estimated to be 30-40% of spent time, money or materials. (Aakre et al 2010). Until the 20<sup>th</sup> century, efficiency has been seen as utilizing resources and lead to cutting processes into small pieces and competency areas. Efficiency calculation shows how effectively resources are used, meaning how much systems are used during the evaluation period. Modig and Åhlström demonstrate example of an MRI scanner: 6 hours of use in 24 hours = 25% usage. Lean management aims to change resource efficiency thinking to flow efficiency. In flow thinking, in the center is the unit going through whole process, not the usage of a single system. Calculation of efficiency is then measured from a need to a satisfying end result. Modigs and Åhlströms example on this: patient with sore throat enters to hospital and gets treated. Time from entering to leaving 30min and time spent at doctor/nurse 10min = 33 % flow efficiency. Only value adding activities are efficient to the patient. Flow efficiency can be reached by processes and understanding all activities inside a process from the unit's perspective. (Modig – Åhlström 2013 p.1-14.)

Lean projects are taking place all over the world in the health care sector and many studies show that Lean concepts can be applied to health care environment. Using Lean concepts, health care operators may gain higher quality and deliver services with lower cost, but also in safety, efficiency and appropriateness. (Kim et al 2006.) Mark Graban lists results achieved in health care using Lean, including shortened waiting times in orthopaedic surgery from 14weeks to 31 hours, increased employee engagement by 15%, reduced patient hospitalization time by 29% and 54 million dollar savings through cost reductions and revenue growth. (Graban 2008 p. 3-4.)

A few Lean projects have already taken place in HUCH and the results are promising. The HUCH department of emergency at Jorvi hospital executed a Lean project and the main result was shortened queuing time for nurse evaluation. Before Lean management, the average waiting time was 10 minutes and after the project only 1,5 minutes. (Niemelä, Anna 2013: Helpot keinot kutistivat jonot). Also the waiting time to get an MRI study shortened in HUS department of radiology in Meilahti hospital after using Lean process. They can produce 17% more examinations meanwhile patients waiting time shortened from 5 weeks to 4,5 weeks. (HUCH Annual report 2011 p. 25.)

### 4.3 Lean Tools

To use Lean management tools it is important to adopt Lean concepts: continuous improvement and respecting people. The first thing is to define a customer and customer needs. After that it is more easy to start classifying value-adding activities. Boundaries of a process must be set for calculating throughput time. (Modig – Åhlström 2013 p.26.)

VSM, or Value Stream Mapping, process mapping or flow mapping has been developed to support supply chains processes. It aims at minimizing waste, smoothening processes and helping information and goods to flow trough whole process. VMS can show hidden waste and help identifying required activities to be able to deliver products or services. To identify wastes, Toyota Productions System has invented the so called seven wastes which should be identified. The main goal is to reduce waste, especially these Non Value Adding (NVA) wastes. (Teichgräber – Bucourt 2012: Teichgräber – Bucourt 2012: Applying value stream mapping techniques to eliminate non value added waste for the procurement of endovascular stents.) VSM helps to visualize the whole process from starting point to an end and seeing opportunities for improvements. (Kim et al 2006). In health care VSM is a tool to identify all the steps a patient goes through in a care path in a certain clinical setting. Process mapping is generated through observation in the real environment and following steps and timing each piece. All participants (staff), transportations, waiting times and interventions are documented. (Cookson – Read – Mukherjee – Cooke 2011: Improving the quality of Emergency Department care by removing waste using Lean Value Stream mapping.)

VSM mapping has three stages. First stage is a current state analysis where all procedure steps are reviewed and delays or information flaws are detected. Future state VSM is created based on the current state VSM. Unnecessary wastes are eliminated from current state VSM, bottlenecks are found, just in time thinking is applied, and specific process improvements are taken into account. (Teichgräber – Bucourt 2012.) New steps try to change waste into value to customer and brainstorming in this point is valuable. After the new VSM is generated implementation and reaching to achieve future state starts. Often there might become a loop between these stages, when implementation and process evolve. After the first Future state VSM is implemented, it may turn into the current state VSM. New improvement ideas arise and generate a new future state VSM again. This leads to KAIZEN thinking, which is a Lean term for continuous improvement. Improvements and progress should become as a part of daily activities. (Kim et al 2006.)

#### Problem-Solving A3 Template

Problem-Solving A3 Template is a straightforward tool to analyze existing problems. One problem and one page helps dealing with several problems separately. Firstly an identified problem is stated and the current workflow is described. Data gathered should be base on live observations. Five why questions are used to find root causes of the problem. After finding a root cause a better solution is presented and implementation phase starts. After implementation, it is important to arrange a follow-up to compare expected results with actual received results. (Kruskal et al 2010.)

To: By: Date:	Goal/Theme:
Current state:	
Target state:	
Cause analysis:	
Implementation: what, who, where,when	
Follow-up:	

Picture 4. Example of an A3 template

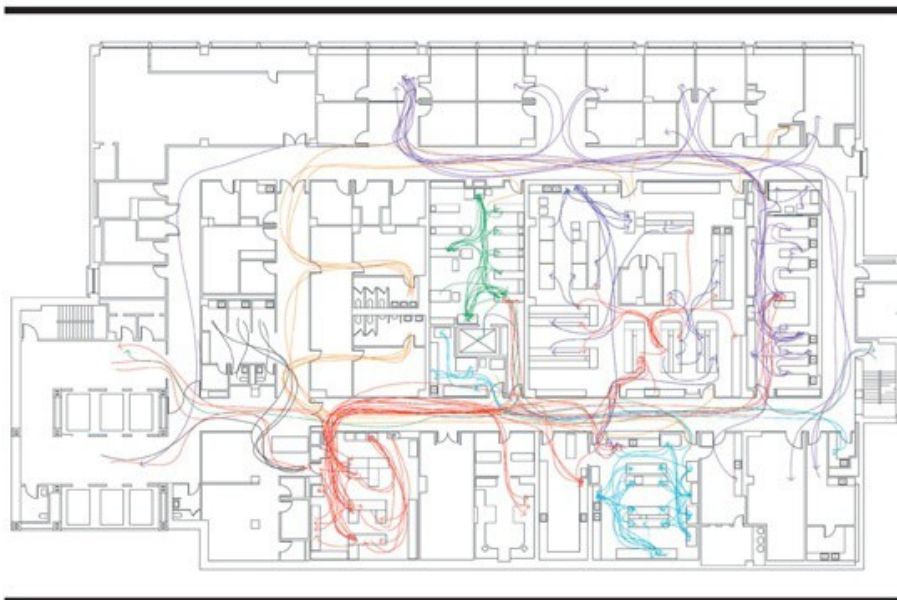
Picture: Henna Lähdeniemi  
(Jimmerson et al 2005 p.253)

## Gemba

Gemba, or gemba walk, means direct observation where actual work is done. It helps to identify what happens in reality, instead of what we believe to happen. Value creation, safety and efficiency can be evaluated during the visit. (Kruskal – Reedy – Pascal – Rosen – Boiselle 2012: Lean approach to improving performance & efficiency in a radiology department.)

## Spaghetti (motion) diagram

Spaghetti (motion) diagram, or Workflow diagram visualizes how people move in a selected environment. In health care it often describes patient, nurse or data path during workflow. The goal is to find unnecessary movement and change routes to shorten them. (Kruskal et al 2010.)



Picture 5. Spaghetti diagram

Picture: HUCH Lean project, copy rights Esko Korhonen, permission of use applied 7.10.14

## 5S

Five S is a tool to improve the working environment. It highlights working safety and improves workflow by placing needed instruments close to the place where they are normally used. The objective is to increase product quality, but reduce waste. It tries to give employees control of their own working place. Additional benefits of using 5S are

following standardized work and reducing variation. 5S is a widely adapted technique in Japan and the term 5S comes from Japanese words:

- 1 Seiri - Sort
- 2 Seiton – Set in order
- 3 Seiso- Shine
- 4 Seiketsu –Standardize
- 5 Shitsuke- Sustain

All processes start with Sort, meaning organizing things and throwing rubbish away. There are three categories for items and where they should be stored. If usage is high (daily/weekly) items should be on working site. If usage is medium (1-2 times a month) items should be in the central storage of the working place. But if items are not used in the past year or once during half a year these items should be thrown away or left in distant storage.

Next step is Set in order, deciding the best places for each item. All tools needed should be easily available. All employees should know the names of items, where they are stored, and all items should be properly labelled. If there are items that have multiple names (actual and nicknames), decide which one to use. If similar products are in use, with minor differences, separate them clearly. To help placing various storing system can be used. Hallways should be clear and without obstacles. (Chapman Christoffer 2005: Clean House with Lean 5S.) Organize things according to the frequency of use. If only the first S is performed, waste elimination becomes more “spring” type cleaning method. Graban has defined storage proximity: items used daily should be within arms reach, items used every shift, within a short walk, items used weekly can be stored a little further, but if monthly items should be in department storage and if only annually, items are store in hospital general storage. This helps to keep good ergonomic in addition to well-organized working area. (Graban 2008 p. 89.)

Shine: According to 5S, cleaning is the responsibility of all employees of a department. In hospitals floors and free surfaces are cleaned and wiped, but there are lots of places with dust and dirt. In health care shine also means taking care of an infection free working area.

Standardize: When the first three S are performed, it is time to ensure that the working environment stays as it is set. All items have standard locations and these can be marked with pictures or labels, for example. Pictures and labels help to realize if some item is out of stock and get quick replacement. Places can also be marked on the floor as well with certain coloured tapes. A surgical instrument basket may have a picture of tool selection in the bottom, making collecting items very easy. (Graban 2008 p. 89.)

Sustain: sustaining helps to stay out of “spring” type cleaning and becoming a part of daily work. Managers or supervisors should have an inspection plan, to keep good order and tidy working environment. Visual guiding and/or checklists may be used to help finding out if something is out of place or missing.

Sixth S can be added in the health care environment to the 5S methodology. S for safety. Safety S can be considered to stay with all other 5S stages, supporting safety in each state. Less items and all in right places causes less changes for tripping. All items easily to reach increases patient safety. Safety S highlights that safety as well as cleaning is every one’s job from grasroot level to executive-level and to management (Graban 2008 p. 89.) Each day when finishing the working place should be clean and tools on the right place. 5S is important tool to support all other Lean tools, and well executed it may help to decrease defects by 50%. (Chapman 2005.)

#### Visual guiding

Visual guiding is making abnormal situations easy to notice. The aim is to make them visible so they can be fixed. This may involve texts, guides, colors or pictures etc. For example in health care colored post card sized papers can be handed to patients to visualize their care needs or different examinations to employees. (Graban 2008 p. 89.) Visual guides can also increase safety by clear warning signals. (Kruskal et al. 2012).





Picture 6. Visual guiding showing items available each shelf.

Picture: Henna Lähdeniemi

**Kanban:** Kanban is a tool to grounding from 5S, visual guiding and standardized work. It helps a department to cope with large numbers of items and inventory. Kanban means in English a card or sign. Kanban is often a card or a bin and it is a visual indication that some item is running out. Kanban card has more detailed information about the item, where to order, quantity, minimum amount when to order more and it's storage place. It can be either physical card or electronic signal, or a barcode. Kanban emphasises right amounts, right place and ensures the employees have all supplies needed, but there are not too many getting old in storage. Building up a kanban system can cost, but in the long run it guarantees better availability with the lowest possible stock. (Grabau 2008 p.101.)

#### Balanced scorecard

Balanced scorecard is a tool to see how metrics match to set strategic goals. It is normally a visual board to follow performance. If there are flaws or deviation, it is visible immediately. (Kruskal et al 2012).

#### Throughput time

To improve entire the workflow, it can be cut into smaller separate processes. Performance dimensions often used to quantify processes are throughput, patient safety and queuing time. As a result, they have an impact on satisfaction, time, cost and quality. For example, potential capacity can be compared to effective capacity. Working time divided by patient cycling time equals the potential capacity of a day ( $TotT/CT = Pcap$ ). Effective capability is the percentage of examinations completed at the first time multiplied by actual availability multiplied by the potential capability ( $FTR \times$



Av x PCap). Calculations can be used to find bottleneck and place where capacity is wasted. These can be availability, low percentage of first-time-right or long idle times. (Mast – Kemper – Does – Mandjes – Van der Bijl 2011: Process Improvement in Healthcare: Overall Resource Efficiency.) In other words, throughput time can be calculated as Little's Law: Throughput time = flow units in process x cycle time. Throughput time is affected by variation, as the greater the variation in the process is longer the throughput time. Managing variation inside process helps to shorten throughput time. (Modig – Åhlström 2013 p.34, 43.)

#### Continuous improvement

In Lean thinking the challenge is to have long term visions and turn them into reality. The KAIZEN principle means continuously aiming for better and looking for new innovations and evolution. Kaizen can be translated as “change is good”. Aim is somewhere in the theoretical perfect state, but in reality impossible to reach. (Modig – Åhlström 2013 p.100.) Kaizen events are gathering people to share new ideas and increase teamwork and spirit. These should be held regularly to encourage Lean culture and continuous improvement. Kaizen needs good planning, execution and follow-up. (Kruskal et al 2012.)

#### Standardized work

Standardized work is needed to maintain certain level of service and finding the best ways to do daily work. Standardized work can be supported with guides, which should be provided by people working, not forced from management. Written guides can help to sustain a selected path, but also to help train new employees or students. Standardized work documents can include check lists, work instructions or capacity sheets. The goal is not to standardize, it is to deliver better care for patients. (Graban 2008 p. 67.)

#### Heijunka

Heijunka is needed to keep standardized work and continuous improvement in balance. Heijunka means workload or load level evenness. Demand for service should be equal each day, avoiding peaks and more quiet times which can change cyclically. These three foundations of Lean, KAIZEN, standardized work and heijunka together support waste elimination, but in a way that respects people. (Graban 2008 p. 67.)

#### 4.4 Lean Projects in Medical Imaging

As tough financial times are putting pressure on hospitals as well, there have been many Lean projects to help increase efficiency and quality. There have been numerous failures, due to adopting only Lean tools, without the operating philosophy. Some projects have been too superficial, leaving root causes of problems unsolved, using a quick fix or workaround for visible problems. But even more there have been successful implementations in different departments. (Mazur – McCreery – Rothenberg 2012: Facilitating Lean Learning and Behaviours in Hospitals during the Early Stages of Lean Implementation).

The radiology department of Mayo Clinic implemented Lean methodology for bone densitometry practice. They chose it because they perform more than 15 000 bone densitometry studies each year, meaning an average of 70 patients each day. Many parts of this procedure had already been optimized, but not the workflow. They spent 20 days learning and implementing Lean. Mayo Clinic gathered a Lean team and used VSM, DMAIC and spaghetti Lean tools to implement this project. Workflow was analysed and timed according to value adding and non-value adding steps. After the project and analysing the results they implemented two changes. Patients filled out a questionnaire while waiting for a technologist, instead of filling it out in the imaging room. They moved the patient waiting area closer to the imaging room. These two little changes saved an average three minutes in each patient cycle, which means 15% savings in time. That means they can perform six patients more each day. Savings came from reduced technologist walking time and shortened in room time. The conclusion of this study was that even small changes can make positive outcomes and often employees do not stop to think how small changes could effect daily routines positively. (Aakre et al 2010.)

Odense University Hospital (OUH) implemented Lean management in multiple departments. The Department of Radiology, Department of Cardiology and Orthopaedic Department were piloting Lean management in OUH. In order to engage staff OUH came up with idea that 55% of gained productivity (time saved) will benefit employees to be used for trainings, conferences etc. In the Department of Radiology they got a consultant to lead Lean management, but they also gathered a Lean team. Two members of the team got certified Lean training. The Lean team learned that it was crucial who leads the Lean team; the leader had to have an inspiring touch and

understanding of clinical settings. CT examinations were the first to start the Lean projects. They used VSM, 5S, SMED and Kaizen with white board with new initiatives and weekly meetings to discuss ideas and implementations. VSM evaluation shorted throughput time from three months to four weeks. They changed workflow by introducing a preparation room, which reduced time spent in imaging room by 50%. The i.v cannula insertion and information giving now takes place in the preparation room, not on the CT camera table. These changes enabled them to perform six more examinations a day and waiting times decreased. Great implementation of Lean on top of increased productivity was that employees started to be more keen on how they work and thinking a new ways to perform. Patient needs were considered more than before and employees got more time for education and meetings to share knowledge. (Karstoff – Tarp 2011: Is Lean Management implementable in a department of radiology).

Duke University Medical Center used Lean Six Sigma methodology to find out how efficient their MRI protocols are. They used very detailed VSM and calculated all steps occurring inside the imaging room. They separated them into value adding, business value adding and non-value adding categories. They compared liver and knee examinations. In liver examinations there was 40,2% of non-value adding steps and in knee only 5.8%. They wanted to study how to shorten MRI table times and acquisition duration. They got nice pictures of cycle times and times when MRI system was actively in use. As a result, they could identify steps in MRI protocols that are ineffective. Previously they had analyzed the workflow before and after acquisition, but this time they got inside the imaging protocols. The conclusion was clear; there is plenty of potential for optimizing protocols and saving minutes in each examination. There were large gaps between acquisitions sequences, and they could shorten table time for patient. Gaps in between were caused by several reasons; MRI system detecting magnet field, waiting time to get the contrast media peak, coil frequency check, coil positioning, table movements, and for long breath-hold sequences imaging must be cut in smaller phases and there was a long break between phases . As a result these parameters were adjusted as well as possible and protocols were standardized. As a example isocentric imaging resulted reduced patient table travelling. Free-breathing protocols could be applied and the 3T MRI system would decrease cycle time (current 1.5T). Conclusion was that Lean is very adaptable in radiology and makes it easy to find improvement needs, even in software protocols. But VSM and workflow analyses must be done by someone who understands the clinical setting.

(Roth – Boll – Wall – Merkle 2010: Evaluation of MRI acquisition workflow with lean six sigma method: case study of liver and knee examinations).

University Hospital of Berlin department of radiology applied a single Lean tool, VSM, in endovascular stent placement workflow. They performed a current state analysis and realized that only 15,4% of the human resources in the process were adding value in procedure. Also, only three steps out of 13 were operational and adding value. Time was spent mainly in movements, stock, transportation or administrative things. Future state VSM started with the elimination of those non-value adding steps. They changed from push to pull mechanism and built a consignment stock instead of ordering 24h before placement from supplier. Out of 13 activities, five could be removed as non-value adding steps. Conclusion was that it is good to understand the whole process, and understanding can prevent also medical errors and save costs. (Teichgräber – Bucourt 2012.)

## **5 Aim and Purpose**

The purpose of project is to guarantee more equal service for all patients having sentinel node gamma imaging, independent on the performing technician. Customer satisfaction can also be enhanced through reliability of care, better quality, more capacity, operational reliability and quicker service (shorter through-put time). Lean tools offer ways to deliver customers value that they need and pay for and help to cut all non-value adding actions. Lean thinking advices how to reduce waste and deliver right service on right time. It supports cultural change in organization to aim continuous improvement and ability to change. Lean management optimizes services and helps understand value chain and workflow. After all Lean tools have been implemented, we will be able to create standardized work, which has little variation and all customers will get the same service. We are hoping to increase the usage level of camera and create guides to support standard work and increase patient safety.

The aim of this development project is to create standardized workflow for sentinel node gamma imaging and produce needed tools and guides to support it.

Development needs were set as follows:

- 1) Develop more standardized workflow
- 2) Increase patient safety
- 3) Increase productivity

## **6 Methodology**

### 1) Data collection methods

Workflow data in this project was gathered using group discussions, where participants were from multiple occupations, doctors, laboratory scientists, radiographers and physicists. The group gathered to discuss four times during spring 2014 and each time there were six or seven participants. The data was also collected with a real environment observation. The live real environment observation lasted for three days and took place in Nuclear Medicine Department MISPI3 gamma camera room, where sentinel node gamma imaging examinations are performed. The observation included five different performing technicians and timing/calculating the cycle and throughput times of the sentinel node gamma imaging workflow. The data was analysed with descriptive methods like calculating frequencies, average imaging times and usage level of camera.

### 2) Lean development methodology

The development project was carried out with Lean methodology. Lean methods and principles are described in a theoretical framework. The next chapter will describe how Lean was implemented in HUCH Medical Imaging, Department of Nuclear Medicine.

## 7 Lean Implementation

### 7.1 Project Plan

- First task was to gather a Lean team, multi occupational and volunteer based group. The aim was to get four to seven people
- Schedule first meeting for Lean team for February 2014
- Define project workflow
- Introduce tools to be used in this project
- Create Volume Stream Mapping
- Implement findings from VSM
- Create Spaghetti diagram
- Implement findings from Spaghetti diagram
- Live observation at least 2 different days
- Schedule 3-5 meetings, according needs and progress
- 5S implementation

The scheduled meetings were planned to be finished before June 2014, before summer holidays. Otherwise project would have been on-hold for two months during the summer and delay a lot. These meetings were held, when five or more team members were able to join. Researcher was resourced to spend as well three days in observation.

Researcher is looking this development project on a professional way and from a quality perspective. A customer experience and service are included into consideration but on healthcare professionals scope. Customer (patient) orientated way needs consideration on customer information, queuing and appropriateness. The surgeons are representing customers as well and their opinions were included into considerations how to improve sentinel gamma imaging service.

## 7.2 Lean Project in HUCH Medical Imaging Center Department of Nuclear Medicine

This Lean project was executed using several Lean tools: Volume Stream Mapping, Spaghetti (motion) diagram, workflow timing/cycle timing, Gemba observation and 5S.

The Lean team consisted of volunteers and was put together from a multi-professional perspective. The team met four times during spring 2014, between March and May. Each time there were at least four technicians, one to two doctors, physicist and I as a team leader. The start up meeting was held in Meilahti parakki meeting room on 26<sup>th</sup> of March 2014 and the last wrap up session was held in 21<sup>st</sup> May 2014.

Table 1. Actual development project schedule, 2014

January	February	March	April	May	June
Research permission					
	Permission accepted				
	Gather a Lean team				
		First meeting			
		VSM			
		2nd meeting			
		Spaghetti	3rd meeting		
			1. observation day		
			2. observation day		
				3. observation day	
				Wrap-up	
					5S implementation

In the first meeting I introduced Lean thinking and methodology behind it and the tools we were going to use. Secondly I introduced briefly what we were going to do during this development project. We agreed that we aim to gain knowledge about waste and how to eliminate it (7 types of wastes), which also influences to patient safety and comfort. 5S was another tool we were going to use later as discussed to improve the examination environment. As Lean methodology advices, our goal was to standardize sentinel node gamma imaging workflow to be independent of operator and amount of examinations performed.

The first important task was to define our customers for sentinel node gamma imaging. We decided that we have two different groups of customers; firstly, patients getting the examinations, but also surgeons receiving the results, images and patients after

sentinel nodes are marked. Patient survey on satisfaction was not planned, but involving surgeons into the project seemed obvious to us.

#### Current state VSM

We analysed the workflow with a Lean tool called value stream mapping (VMS). We chose to use post it notes and marker on a base paper. The post it notes are easy to remove and replace when needed. We started by defining the participating people and discussing if workflow can be cut into smaller pieces. The main goal of VMS is to reduce waste by eliminating Non Value Adding (NVA) activities.

People involved in sentinel node gamma imaging were defined as follows:

- 1) secretary (nuclear medicine department)
- 2) technician (laboratory technician or radiographer)
- 3) doctor
- 4) physicist
- 5) patient
- 6) referring department (breast surgery department)

We discussed current workflow and segmented the workflow into three parts:

- 1) Prior to patient arriving to department
- 2) Patient preparation
- 3) Imaging

The first part consist of events taking place before patient enters to department, mainly one day before. The second part includes things happening at the department, but prior to gamma imaging, and the third part are things happening during imaging and after that. (Appendix1)

After defining the key players and workflow segments, we started to placing actions inside the workflow in the current state. The workflow starts at the referring department writing a referral to sentinel node gamma imaging. After referral they independently book an appointment for each patient on the Oberon appointment system. In addition to referral to sentinel node examination they book blood tests for every patient. Once the appointment has been booked, the secretary at the Nuclear medicine department



verifies that referrals are in place for every patient. Nuclear medicine department doctor accepts the referrals prior to the examination and a technician checks one day before that all referrals exist for the next day patients and all referrals are accepted by our doctor. On same day that patient enters the Nuclear medicine department; the radio nuclide tracer is produced and gamma camera quality assurance programs are run. These are performed by a technician in the morning.

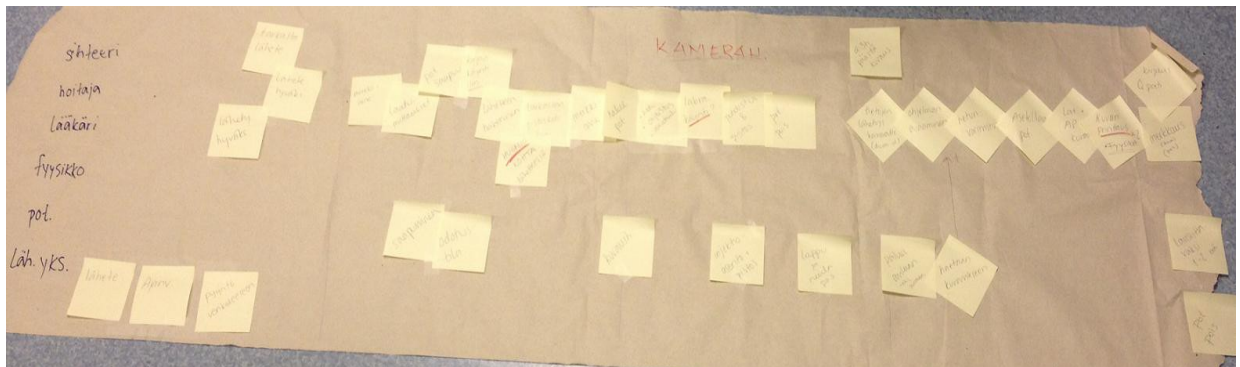
Once a patient arrives at the department he/she is registered for examination by the secretary and instructed to wait in the lobby. The technician fetches a referral from the secretary and verifies the injection side and exact place from Qpati program and draws and measures radio nuclide tracer dose. When the tracer is in a lead box the patient is called into the camera room.

The date of birth and social secure number are verified with the patient, and the technician informs the patient about the schedule, injection and imaging. The patient undresses her/his upper body and is placed laying on the back with the injection site arm stretched to the side. The technician cleans the injection spot and injects the tracer in the skin (intra dermal injection). The injection site is covered with a clean swab and taped. Information about laboratory visit may be given and the patient leaves the room.

After two to three hours the patient returns to the lobby and the technician sends patient information from dicom worklist to camera and opens up the correct imaging program. Date of birth and social security number are verified again when fetching the patient from the lobby to the camera room. The patient undresses her/his upper body again and is brought to a supine position on the imaging table. Images are acquired in AP (straight) and lateral positions. Images are printed afterwards, in two copies, one for the patient and one for the doctor dictating the study. The technician picks up the prints and enters the camera room to mark sentinel nodes on the patient's skin. Sentinel nodes are marked with a permanent marker with an X on top of each node. The patient then dresses up and leaves the department. The technician finalises the study by registering the study as finished in Qpati and takes the referral to the doctor.

After value stream mapping, we had a nice visual paper and additionally we had our current workflow. (Appendix 2) To be able to see if there are some unnecessary movements we draw a spaghetti diagram. We drew current patient path with black and

current technician path with black also during sentinel node gamma imaging study. With VMS and spaghetti tools we found clear improvement needs.



Picture 7. Sentinel node gamma imaging workflow VSM

Picture: Henna Lähdeniemi

#### Future state VSM

To make changes and to understand what needs to be changed requires understanding on the present state, but also what we aiming for. From the current state we turned our minds into the future state and how we would like this workflow to be, and also what the problems or bottle necks of the flow are.

Feedback from our doctors started immediately when we started to think about things prior to the patient coming to the Nuclear medicine department. There is a constantly recurring problem and it is the referral that comes from the surgeons. The referral should pinpoint the exact location where the tracer should be injected. It takes too much time for the technician and doctor to find out where to inject, if this is not mentioned in the referral. It requires phone calls, seeking in the Miranda patient information system or an arbitrary decision where to inject. They should also be aware that the tracer is injected intracutaneously (i.c), not subcutaneously. This affects how fast and well tracer starts to spread.

If breast cancer is marked with a radioactive seed surgeons require that the tracer injection is performed at least four cm away from the seed. But there is a practical problem, that they do not often write where this seed is exactly located, or they ask for injection to different quarter than where the tumor is. Normally the injection should be applied into same quarter as the tumor. Coordinator doctor was in touch with surgeons and their coordinator about the seeds. Problems occur if the injection site is close to

the seed, since it hides the visibility of the seed and the surgeon needs to remove more breast tissue. Also they needed to agree on if we are entitled to inject to a different quarter than the tumor. Surgeons request that sometimes, but our guidelines are against it.

Breast sentinel node injections were previously given by the surgeons, but when Women's hospital went under renovation, tracer administration was moved to the department of nuclear medicine. This started in the spring of 2013 and at first doctors gave the injections for one to two months, but it was too time consuming for doctors so the task was given to technicians. Task once performed by surgeons became daily work for technicians. There were not very clear instructions and the doctor responsible for teaching was retired. First injections were given into the tumor, then under the skin and finally into the skin. Specifications for how to inject would be more than welcome. Doctors explained that there is no effect in which direction the needle is inserted into the skin, if the place is correct. This was not very clear at the moment and has caused some problems with ergonomics. While injecting it is important that there is no tracer contamination on the skin.

Patients going to surgery from sentinel node gamma imaging will also need some laboratory tests as well. There are multiple ways when/where those are taken, and they have received instructions beforehand. There should not be a need to find out how they are prepared, but we can point out that there is a laboratory in the third floor, if needed. Patients have lots of time to go there before imaging, because images are taken roughly two hours after injection.

A need from doctors to technicians was that there should be clear sign where the tracer was injected. This could be a text, picture or similar clear indicator.

For physicists there came up a few things to solve. There is a printer in a shared space next to the MISPI3 camera room (control area), but it was not in use. The technician needed to print out the sentinel images to a printer in the physicists' room, which is on the other side of the department. Image print is needed when starting to mark sentinel nodes on patient skin to visualize them better. It comes to patient safety as well not to leave the patient alone waiting in the room. An other problem found was which system to use to print out those images. We use Pegasys, Hermes and Portal, but there should

be only one to be used. Images should look the same or similar and it is the physicist's role to decide which to use in order to deliver similar images.

The secretary prints out the referral once patient enters the Nuclear medicine department. The problem is that if a doctor writes some comments to the referral those are not visible in the printed version. There is either Qpati number (examination number) or comments on the printed referral but in ideal case there should be both. It is a safety issue that comments are not visible in the printed referral which is inside the room when patient gets the injection.

We realized that there is a huge waste in 8-10 am every morning in resources, when the camera room is booked for injections. A sentinel injection does not need a camera room, and there is an empty room available at the department (L 121 in floor plan, Appendix 2). If injections are moved outside the camera room, there is a possibility to do one other examination on Monday to Thursday mornings. The camera is suitable for doing oesophagus, lymphatic system and kidney function studies as well. New timetables in Oberon will be arranged to book examinations to MISPI3 on mornings. Secretary was informed already and others will be informed on Monday morning meeting. This solution will ease workload on the other cameras.

We wanted to find out how effectively the camera room is used and how long the patients wait when they get the injection and when images are taken. Normally there are one or two technicians working in the sentinel node room. We wanted to compare two identical days with one technician and the other with two technicians and see if there is real time saving or is it just a waste of resources to place two technicians to work there.

#### Throughput time

Researcher spend three days (not identical) timing patient flow identifying waiting times, injections times, delays between injection and imaging and imaging times. On purpose one day there was one technician working, and the second day there were two technicians working. The last day was split between 1 and 2 technicians. This was better for having more variation between days and the number of examinations performed. (Figures 1, 2, 3 and Tables 1, 2, 3)

## 2<sup>nd</sup> April 2014

On the first observation day 2<sup>nd</sup> April 2014 there were two technicians working full day. They performed eight examinations together. They started injections at eight and finished taking images just before two pm. Times were recorded in minutes, not seconds.

Table 1. Two technicians, eight examinations cycle times

Registration	Into room for injection	injection	Out of the room	Into room for pictures	Examination	Markup	Finished	other
7:35	8:10	8:14	8:17	10:05	10:08	10:20	10:27	
8:03	8:20	8:23	8:26	10:29	10:33	10:48	10:56	
8:04	8:28	8:31	8:34	10:58	11:02	11:16	11:23	
8:24	8:37	8:40	8:43	11:29	11:33	11:47	11:53	
8:54	9:08	9:11	9:14	12:19	12:22	12:35	12:41	
8:43	8:51	8:55	8:58	11:53	11:56	12:08	12:14	
8:57	9:22	9:25	9:27	12:44	12:46	13:03	13:21	addit. injection 13:17
10:07	10:10	10:15	10:18	13:00	13:27	13:40	13:46	lnj.room

Each injection was performed right after the previous one or right after the patient arrived. After starting the imaging part, there were no breaks in between.

## 24<sup>th</sup> April 2014

On the second observation and timing date 24<sup>th</sup> April 2014 there was only was technician performing sentinel node gamma imaging examinations. The technician examined four patients during the day. The usage level of the camera room was 100% between 10.30 am to 12.30 pm, but only during that two hour time period.

Table 2. One technician and four examinations cycle times

Registration	Into room for injection	injection	Out of the room	Into room for pictures	Examination	Markup	Finished	other
7:47	8:07	8:10	8:14	10:35	10:39	10:54	10:59	
7:36	8:21	8:27	8:30	11:02	11:05	11:22	11:22	
8:08	8:37	8:41	8:44	11:34	11:38	11:55	11:59	
8:44	8:55	8:58	9:02	12:01	12:06	12:20	12:24	

## 13<sup>th</sup> May 2014

The third observation and timing day 13<sup>th</sup> May 2014 was split. In the morning there were two technicians working and in the afternoon only one. Patients one to five were performed by the pair and patients six to eight by a single technician.

Table 3. One technician and two technicians eight patients cycle times

Registration	Into room for injection	injection	Out of the room	Into room for pictures	Examination	Markup	Finished	other
8:03	8:05	8:11	8:14	9:58	10:00	10:25	10:29	
8:04	8:16	8:20	8:22	10:30	10:32	10:50	10:54	
8:05	8:27	8:30	8:33	10:53	10:56	11:13	11:18	
8:13	8:36	8:40	8:45	11:22	11:25	11:40	11:45	
9:11	9:16	9:19	9:23	11:48	11:50	12:04	12:07	
9:25	9:38	9:41	9:46	12:24	12:25	12:41	12:47	
9:19	9:29	9:33	9:35	12:41	12:44	13:09	13:13	
10:15	10:20	10:27	10:29	13:17	13:20	13:36	13:41	

The usage of the camera room was higher than on the other observation days, but still images were taken between 10 am. to 2pm. This means four hours of actual usage of camera room for imaging.

On all these followed and timed days patients arrived often before their scheduled times. Nevertheless, most waiting times were acceptable. On the first day the average waiting time prior to the injection was 17 minutes, on the second day 26 minutes and on the third 11,5 minutes. But if the injection time was compared to the scheduled time, most patients got their injection ahead of schedule. 13 patients out of 20 got their injection either precisely right on time or earlier than scheduled. Only seven patients out of 20 had to wait longer than their scheduled time, and the average waiting time was eight minutes. The longest waiting time was 17 minutes over scheduled time. On the other hand, two patients got their injections half an hour earlier than scheduled.

If we compare waiting times (only those who had to wait longer than scheduled time) and the amount of technicians working, there is no evidence that patients need to wait less if there are two technicians working. Actually, on the first day when there were two employees, the waiting times were the longest among the observation days: 11 minutes on average (four patients). On the second day, with one technician the average waiting time was four minutes (two patients). On the last day where there were two technicians working, average waiting time was five minutes (one patient) and during one technician working the rest of the day, there were no delays at all.

The time between injection and scanning may vary between one to four hours, but this was timed to see if there was a significant difference whether there was one or two technicians working. All examinations started within an acceptable range. Less than

two hours between injection and scanning were found in both groups as well as more than three hours in between.

The main interest in timing was to see if sentinel node examination can be performed faster with two technicians. The examination time includes the time that a patient needs to undress, the imaging, skin marking and patient getting dressed. On the first day, the shortest examination time was 21 minutes and the longest 37 minutes, an average of 25 minutes. On the second day the shortest examination lasted 20 minutes and the longest 25 minutes, giving an average of 23 minutes. On the last day with two technicians on duty the shortest examination was 17 minutes and the longest 29 minutes, giving an average of 22 minutes. On the same day when there was one technician working, the shortest examination lasted 20 minutes and the longest 23 minutes, averaging to 21 minutes. Overall two technicians performed examinations more slowly than one technician by one to two minutes longer on average.

## 5S

We implemented the 5S philosophy to MISPI3 camera room 11<sup>th</sup> June 2014 afternoon. We started by sorting out things that do not belong to that room and other unnecessary things. We found plenty of things out of date and ready to throw to trash. We cleared the patient undressing area so that there is room for personal belongings on window shelf. All window shelves were cleared for easier cleaning and a more peaceful environment. We decided that there is no need for two trashcans, and a trolley tray found a parking space. The one trashcan was placed on the wall to save some more space on the floor. We gained a lot of space in the working area, and the shelves on left side of the room are now reachable. We placed items where they are mainly needed and labelled cupboards and shelves clearly.

We separated items that are not used in this examination or other examinations performed in the MISPI3 camera room. They were placed back to the storage room or to another imaging rooms.





Picture 8. Items non-usable in this room

Picture: Henna Lähdeniemi

We also found items that are pure waste. Items that were expired, even years ago, ruined or non usable anywhere at the department. Those were thrown away.



Picture 9. Expired/rubbish items

Picture: Henna Lähdeniemi



## 8 Results

After this development project, we were satisfied with 11 clear improvements applied in the sentinel node gamma imaging workflow. They support standardized workflow increase patient safety and increase effectiveness. Improvements applied in the workflow are listed and described below.

Results supporting standardized workflow:

1. Hermes, Dicom worklist and imaging guides
2. Fixed injection method
3. 5S working environment improvements
4. Necessary resources to perform sentinel node examinations

Results increasing patient safety:

5. Smaller injected radiation dose
6. Printer close to the camera
7. Breast stickers to mark the injection site
8. Information field visible on the accepted referral

Results increasing efficiency:

9. More free camera time in the mornings
10. Co-operation with referring physicians
11. Information given to patient about laboratory tests
  - + 5S working environment improvements

### 1. New guides

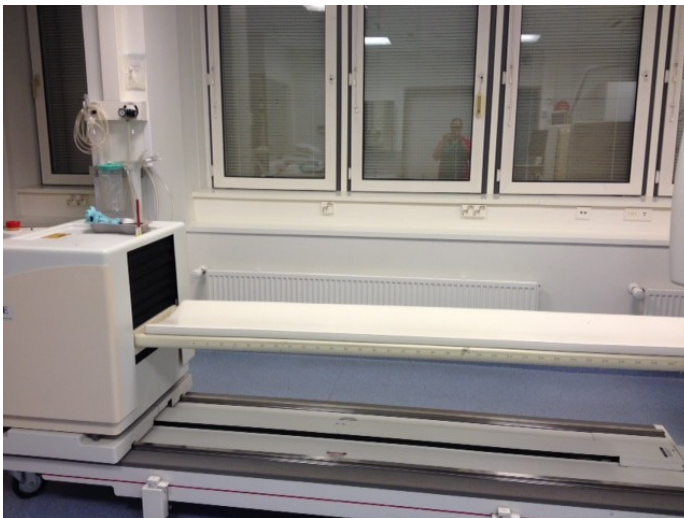
When standardization of work is achieved it requires proper guides to sustain it in the long run. Non-existing guides were produced for Hermes printing and importing patient information from Dicom Worklist to MISPI3. An updated guide for sentinel node imaging was also introduced, including changes about the tracer volume, time between injection and imaging. Old information was removed and information was added about new guides for Dicom and printing. (Appendices 5-7) Guides are in digital format in the operations book, but paper copies are found as well in hard folders where imaging occurs.

## 2. Injection method

Discussions about injections and technique lead to a good solution. We had a doctor monitoring injections and workflow for on day. Later she had a session for technicians performing sentinel node injections. She explained and showed how to given an injection. This was the first time for technicians to have a proper training concerning intracutaneous tracer injectios. The injection method became very clear concerning the injection site, close to aeriola (2-10mm), and also concerning intracutaneous injection and needle position. Volume injected should not exceed 0,2ml and NaCl is not added. Air bubble can be used to assist tracer to be fully injected into patient, but air should stay in the syringe. Internal guide was delivered to technicians by the doctor. (Appendix 8)

## 3. 5S

The 5S method cleared the imaging room. All window shelves were cleared of sheets, pillows, toys, armrests and other items that were lying there and obstructing proper cleaning.



Picture 10. Cleared window shelves

Picture: Henna Lähdeniemi

All items left were given a dedicated place, like the trolley, which normally stood in the middle of the room obstructing free walking. The number of bins reduced to one and that one was planned to be hanged on the wall, instead of placing it on the floor. The

room is clear and tidy making it more professional environment. Items are placed close to the place they are normally used, making them easy to reach.



Picture 11. Trolley and laundry bag found their places

Picture: Henna Lähdeniemi

Cupboard doors got labels that show what is inside. The shelves were labelled as well.



Picture 12. Labelled cupboard doors

Picture: Henna Lähdeniemi

All items placed in the cupboard and trolley have marked spots and the numbers of items were reduced. Only what is needed daily will be stored, not more.



Picture 13. Well organized shelves, only necessary items are available at the right numbers.

Picture: Henna Lähdeniemi

#### 4. Throughput time

Observing and timing the workflow cycle time in sentinel node gamma imaging on three days gave valuable information. We expected that there might not be significant difference in delays and examination times whether there are one or two technicians working. Waiting prior to the injection seemed to be caused by patients arriving earlier than scheduled times. Only seven out of 20 patients had to wait overtime. It did not seem to shorten waiting time at all if there were two technicians working, rather the opposite results came up. Longer waiting times can not be explained only by two technicians working either, but it raises a question about communication and team work. Difference was quite small though, but at least we can say that the waiting time for the patient was not any longer, if only one technician was working.

Examination times were timed as well and comparison was done with one and two technicians working in same room. As in waiting times, the examination times were no shorter when two employees worked together. Timing shows that actually examinations performed by one operator had shorter times on average. Because in both groups there was quite large variation in examination times, this might be more dependent on patients than the number of performers. Some patients are faster to undress and dress, which can affect a few minutes in total time. Some variation may be explained by number of visible sentinel nodes as well. Sometimes there is only one node to mark and sometimes up to seven.

To generalise this information and timing, we can say that it is not any faster for the patient if there are two technicians working. This means one employee is able to perform (in these metrics) as well as two, or even better. There should not be any need to place two technicians in sentinel node examinations, if there are no extra resources available.

#### 5. Radiation dose reduction

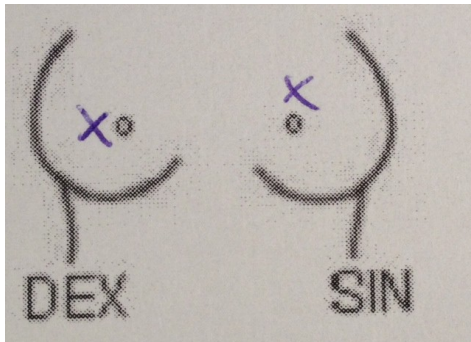
The coordinator doctor was given a task to discuss radiation doses with colleagues. In worldwide comparison Meilahti uses higher doses than most other units. The average dose used is 40 MBq and we used 80 MBq per injection. The timing between injection and imaging is not tight and can vary from two to four hours. This was changed into internal guide lines. After consulting referring surgeons, our doctors came to the conclusion that we are able to use reduced doses. During two week period all patients got 40 MBq injection doses and after that test period it became new standard.

#### 6. Printing

The printer problem was sorted out by a physicist and we can now print out images to nearby printer. This reduces walking distances as shown in the spaghetti diagram. (Appendix 2). Not only do the employees benefit, but this also increases patient safety. The performing technician can nearly see patient even when picking up prints, but at least hear all the time if something comes up. The distance from camera room to printer was a long way in the hallway, nearly 20 metres one way meaning a one minute walk away from the patient. Now this distance is 2m one way and in the same space. This means no time away from the patient.

#### 7. Breast stickers

As a request from the doctors, we created a sticker for indicating clearly where the injection was given. There are breasts and side markers on the sticker and technician will mark the exact injection place with X on the sticker. (Appendix 3). This was implemented immediately and already works nicely and looks professional. Technician can also mark on the sticker if injections were given in both sides. Stickers are applied on the referral after injection, giving clear information about the injection spot.

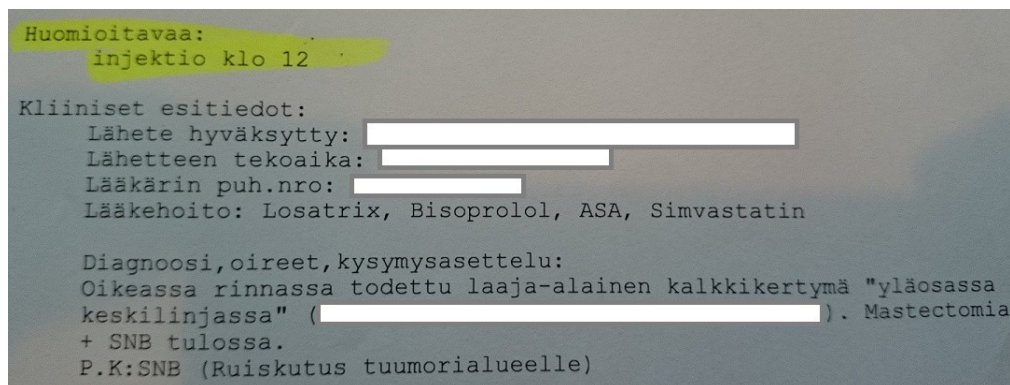


Picture 14. A breast sticker with two marked injection sites

Picture: Henna Lähdeniemi

#### 8. Information field visible on the accepted referral

Information field lacking from the printed Qpati referrals was sorted out as well. Now the comments visible and printed nicely on top of request text on a separate line. It is easy to see quickly if some special needs are mentioned by our doctors.



Picture 15. Information field visibility in referral

Picture: Henna Lähdeniemi

#### 9. More free camera time, new injection room

As shown in the workflow chart, there is a huge waste of resources at 8-10 am every morning, while the camera room is booked for injections. A sentinel injection does not need a camera room, and there is an empty room available at the department (L 121 in floor plan, Appendix 2). While injections will be moved outside the camera room, one or two other examinations can be added Monday to Thursday mornings. This will benefit 1-8 patients each week. The camera is suitable for doing oesophagus, lymphatic system and kidney function studies as well. The Oberon appointment system now has a time slot for one to two examinations on this camera in the mornings. This solution



will even out the workload on the other cameras and Fridays, when other than sentinel node studies are performed.



Picture 16. New Injection room

Picture: Henna Lähdeniemi

Observing and timing the sentinel node gamma imaging workflow was transferred into graphic figures, it visualizes easily the usage of the camera room. On the first day 2<sup>nd</sup> April 2014 there were two technicians working full day performing eight examinations.

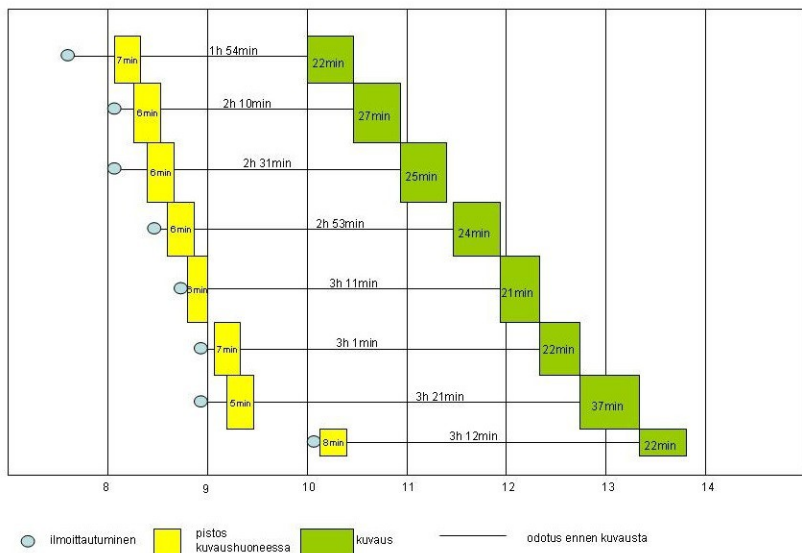


Figure 2. Usage of camera room in 2<sup>nd</sup> April 2014

The second observation day was 22<sup>nd</sup> April 2014 and during that day there was only one technician working and four examinations were performed.

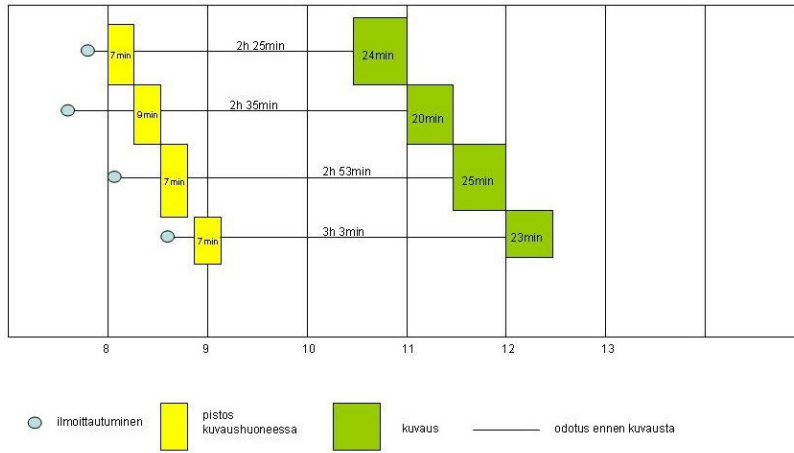


Figure 3. Usage of camera room in 22<sup>nd</sup> April 2014

The third observation and timing day was 13<sup>th</sup> May 2014. There were two technicians working morning together and in the afternoon only one technician continued performing sentinel node gamma imaging. Eight examinations were performed, five together and three by one technician.

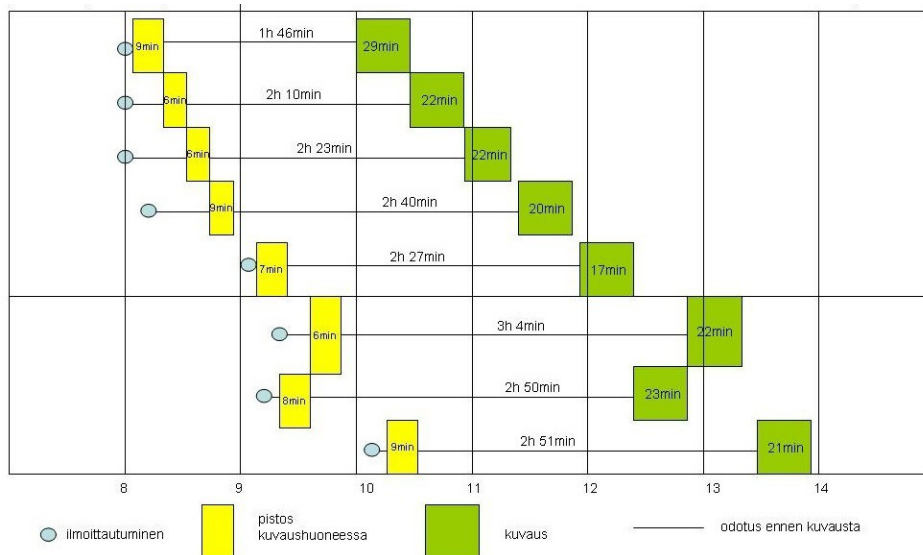


Figure 4. Usage of camera room in 13<sup>th</sup> May 2014

All three days together camera was in use only on average 3,3 hours per day. In the mornings it was misused as an injection room and empty in the afternoons.



#### 10. Co-operation with referring physician

Referring surgeons are our department customers as well so it was important to consult them, how they would like us to improve our service. Reduced dose will serve them better to see only sentinel nodes, not secondary nodes. In good spirit doctors agreed to have more clear on referral where to give injection. Seed problem roots from their probes that can not differentiate radiation from seed and injection. Because of that reason it is justified to give injection in different quarter than tumor. Referring surgeons explained as well that they know that injecting other quarter than tumor is not how it should be, but in some cases, it's only way to avoid too close injection to seed.

#### 11. Laboratory testing

Patients going from sentinel node gamma imaging to surgery they need to do some laboratory tests as well. There are multiple ways when/where those are taken, and they have got a good instructions before hand. There should not be a need to find out how they are prepared, but we can point out that there is a laboratory in 3dr floor, if needed. Patients have lots of time to go there, before imaging, because images are taken roughly two to three hours after injection.

## 9 Discussion

The team for the Lean project was easy to put together, but we struggled to arrange the first meeting. Therefore we started a little behind the schedule. The original plan was to have the first meeting in February, but we started early in March. After the first meeting we sped up the schedule and finished on time, before summer holidays. To be able to maintain the schedule we held the remaining meetings frequently and those lasted a little longer in order to reduce the number of meetings..

A Lean project should be built towards goals, where means define how to realise a Lean strategy (Modig p.142). Defining a workflow for this Lean project was more difficult than expected. There are two types of sentinel node examinations at HUCH Medical Imaging Center Department of Nuclear medicine and the first idea was to include them both in this Lean project. But it became clear that we can not combine in this project both breast and melanoma sentinel node examinations. After renewals at the department breast and melanoma sentinels are examined in different camera room

and with different type of workflow. Because of this change, we decided to concentrate on sentinel node gamma imaging in breast cancer.

Project implementation followed the project plan well, and resources needed were available well enough. Time was arranged for development project team to participate meetings and released from routine work. Meeting times were considered according to the operation of the department and held mainly on afternoons, when work is more flexible. Observation days were arranged when it was possible to release the researcher. We could arrange three days, but more days would have been beneficial. 1-3 days more would have given more detailed information and more variation on employees and examinations. 5S implementation was performed with a smaller group of four people. More human resources would not have given any additional value. We had more or less ideal amount of human resources available during the project.

As financial times are getting harder also hospital have turned to Lean management to solve efficiency and quality problems (Mazur et al 2012). In all Lean studies I studied, a common factor was the aim to improve service. Lean methodology offered ways to deliver the exact cure. Lean projects deliver different results, depending on the goals and the selected Lean group. VSM is an important tool to adjust the project exactly to improve the right things. But in all projects there are clear results and efficiency has increased the way or the other. Many Lean studies have resulted in shortened queuing time (for example Cookson 2011; Karstoff 2010). In Emergency department queuing shortened approximately by 20 minutes (Cookson 2011) and in HUCH Jorvi emergency queuing shortened from 10minutes to 1,5 minutes. Even tough the way sentinel node gamma imaging workflow is today there is no need to shorten queuing time. Patients are getting sevice mostly on time and even before scheduled times.

After this Lean project was finished we were glad to see that the Kaizen spirit was still holding strong. The continuous improvement culture has continued and employees are more keen on looking for a new solutions. As Suuronen writes; Lean is more a change in culture, than just set of tools (Suuronen – Matila – Henner 2014: Lean thinking in the department of radiology). Also in Oulu University hospital employees have been open minded to adapt Lean and develop their ones own work. Their short Lean period also gave promising results and the Lean culture was found in there also. (Suuronen et al 2014.)

## 9.1 Standardized Workflow

Graban states in “Lean hospitals” (p.113) that most errors occur because of human actions caused by problems in processes, systems or conditions. It is important in Lean methodology to recognize the actual pieces of workflow that add value and remove waste. VSM was a very good tool to inspect the sentinel node gamma imaging workflow and find both value and flaws. Lean aims to look for waste and remove it from workflow (Graban 2012 p.37). Before the Lean project, different kinds of wastes existed. After the Lean project, there was a more simplified workflow to follow.

The VSM technique was one of the most used tool in Medical Imaging Lean projects. Cookson (2011) states that they found 300 instances of waste and improvement needs. It is easy to apply and delivers instant results. Our 11 changes seem small compared to 300, but Cookson’s study involved much more complicated environment that included the whole department. In Teichgräbers (2012) example of stent procurement of endovascular stents only two out of 13 activities were adding value.

In a Lean project, part of standardizing a workflow is to set roles and responsibilities. (Graban p.74). But as found in results, this examination type needs only one performing technician. Therefore there was no need to define roles and responsibilities more than they were before the Lean project.

## 9.2 Patient Safety

Especially in the context of radiology it is important to try smoothen patient path and make it as fluent and comfortable as possible (Suuronen et al 2014). Most of the results of this project are linked directly or indirectly to patient safety. Thus, the main finding in this development project would be that we could improve patient safety even though we did not change major things, but small things. As Graban writes, one of the key elements in Lean is to improve quality and increase patient safety by preventing errors. This we could deliver by removing expired items and clearing working/ imaging area from obstacles. Also visual stickers and comments on a referral prevent from making mistakes.

The 5S working environment improvement tool was used in at least one other Lean project (Krushkal et al 2012). It was highly recommended and claimed to find more time

for the staff (Karstof 2010). However it has been stated that inadequately implemented 5S will render other Lean tools and implementations ineffective (Chapman 2005.)

### 9.3 Efficiency

Lean is a strategy that aims to deliver value. It can be achieved with high resource and flow efficiency. (Modig p.127). Flow efficiency was increased, but we were not able to increase resource efficiency and amount of examinations performed on a daily basis. But according to Modig, it is more important to concentrate on flow efficiency. Released camera time will be used for another type of examinations and will benefit multiple patients every week and work for a pull mechanism. A similar solution to release camera room to actual imaging was found in a bone densitometry study where patients filled out a assessment form in the imaging room (Aakre et al 2010). In an other CT Lean project, preparation work, i.v cannula insertion etc. was moved to a preparation room, like we did. (Karstof 2010).

Taner and Sezen (2007) state that there is a path with Lean to increase quality, efficiency and cost-effectiveness. We found that sentinel node examination is for one technician; when two technicians were working simultaneously, it actually slowed down the imaging process. Decreasing the number of technicians actually increased flow efficiency. Placing two technicians to work there is wasted resources, but also a more ineffective way of working. Similar misused resources were found in a CT scanner and two radiographers working there, whilst most of the time one was enough (Mast et al 2011).

Another common outcome of a Lean project is to deliver more by shortening the trough-put time (Roth 2010). After a Lean project in HUCH MR could perform 17% more examinations in a day, and in bonedensitometry cycle time was decreased by three minutes, meaning a 15% reduction on average (Aakre et al. 2010). In one CT Lean project the spared time in preparation cumulated into 900 more patiens in a year (Karstof 2010). In our development project, there was no need to perform more sentinel node examinations, because referring clinics can only perform a certain amount of surgeries. This is the number of sentinel node examinations we perform. Therefore there are no big differences between days, normally four to seven examinations. The highest amount we could deliver in one day would be 10, but most

likely this will not be requested anytime soon. However we could increase the total amount of examinations delivered in a day.

At least a few studies highlights (Komashie et al 2007; Bushell, Mobley, Shelest 2002 – Discovering Lean thinking at Progressive Healthcare) that active participation by ground level employees delivers succesful Lean projects. A pride in one's own work and team spirit lift up the during process confirm reasons for Lean team's success. However, there has not been reported to be incerease in employee satisfaction as an outcome of a Lean project. (Clark et al 2013).

#### 9.4 Ethical Issues

Research permission was applied from HUCH in January 2014 and it was granted 5<sup>th</sup> March 2014. All Lean team members were informed about how this project will proceed and highlighted it is voluntary to participate. Healthcare professionals were well informed about the aim and purpose as well. The project did not include any patient data or similar sensitive material, but people that participated are anonymous. Material was produced through group discussions and to be able to do a development project it is important that participants are all real employees in the selected department, and live cases are the most reliable way to gather information. All phases of the project are described and documented in as detailed way as possible.

The topic of this research project was selected with the medical director and according to the department's needs. The topic is justified because the selected study is one of the most common ones in the department and it touches one in eight women in Finland. Sentinel node gamma imaging study is a FINAS accredited examination, so it should fulfill all quality requirements.

All quality management systems are based on the same principles; gathering data, analysing the data and implementing new ideas. Lean methodology was selected, because it is widely used in healthcare environment. There are numerous studies of Lean implementation in Radiology departments because of its unique customer focus. Everything is based on the idea, that the customer is the one defining the value. Lean management also offered good and clear tools to start with. It suits well a development project because of its plan-do-check-act nature and the objective that data collection method should be direct observation. Lean management was simple enough to start

with and it encourages employees to participate. Six sigma felt too statistical and the costs of six-sigma belt training would have caused problems. TQM seemed partially similar with lean methodology, but did not give such practical tools to start with.

This development project was produced with good ethical manners and honesty. All citations and references are marked correctly, giving credit to original writers. The development project is objective, and doing Lean management as a team increased reliability. All members have had a strong impact on the selected actions. Personal opinion of the researcher was avoided during the whole process. This project is a single development case and it's results cannot be generalized too much.

This project is based on a strong theoretical framework. Books and articles all quite recent. No reference sources older than 12 years are used. References are both national and international publications, and all articles are peer reviewed.

#### 9.5 Reliability

The development project content came from the working place and it was very practical. The selected workflow is one of the key studies in the Nuclear medicine department and was well justified. Researcher had some interest in sentinel node gamma imaging as well. The reliability of a development project can be divided into four categories as follows: credibility, transferability, dependability and confirmability. (Kananen, Jorma 2012 – Kehittämistutkimus opinnäytteenä). Before deciding a methodology for this development project, the researcher familiarized herself with different types of quality tools, which increases credibility. It is clearly explained why Lean methodology was selected from all available tools. It also increases reliability that all phases of the project are described and documented as accurately as possible.

The relevance of this development project is very high. There was an actual need to improve this workflow and we found several things to improve. The goals set in the beginning were met and the activities that were performed are consistent with the expected outcomes. We aimed to standardize the sentinel node gamma imaging workflow and all implemented results fall into that area. Observation and data gathering was accurate and measured real cycle time in the selected study. In qualitative research, reliability depends on how well the research process is described and documented (Kananen 2012 p.173).

Trasferabilità means if results may be used somewhere else. (Kananen 2012 p.175). All development projects are unique and direct transferring is difficult, but at least in the HUCH area there are other Nuclear Medicine departments and they may find these results useful. There are results that are directly transferable, such as arranging a separate injection room, the breast stickers and the use of the 5S working environment improvement. These are easy to adopt and they could become a new golden standard in sentinel node gamma imaging. Other changes may not be applicable in other departments because they may have a different kind of workflow or layout of the department and the amount of performed examinations may vary a lot. These results can be seen more as a trigger to start more projects in other Nuclear Medicine departments, for sentinel node gamma imaging or other workflows. It is applicable that Lean methodology can be used in a Nuclear Medicine department context.

#### 9.6 Further Development Ideas

The sentinel node examination is very client centered, and the patient is a part of this imaging process. Because Lean methodology often aims to increase also patient satisfaction, a further development idea would be a patient opinion survey. A satisfaction survey could be conducted before and after Lean implementation and see if there is significant improvement as well.

During this development project and reading the material it also came up that all results are considered from an organization's or patient's point of view and not from an employee's perspective. Further research could cover how employee satisfaction has changed after a Lean project.

Since we had to exclude melanoma sentinel node gamma imaging examinations from this study this would be a good starting point for the next Lean project. The Nuclear Medicine department is more aware of Lean and will probably run other Lean projects at the department. A culture of continuous improvement drives towards more changes in the future and it would be beneficial to "Lean" all workflows at the department.

## 10 Conclusion

Based on this development project and other Lean projects implemented before, it is fair to say that Lean methodology suits for medical imaging process improvements well. Radiology and Nuclear Medicine departments are quite similar and have plenty of potential to benefit from systematic Lean adoption.

Our goals of finding ways to standardize sentinel gamma imaging were fulfilled. As Modig and Åhlström state in “This is Lean” people always causes natural variation, because of the individual difference in direct or indirect needs. Keeping in mind that we are examining individuals and that cannot be standardized, we could standardize the framework quite well. We found maybe more results than we expected and hoped for. One team member even thought in the beginning that this process has already been fiddled. But once we got started it became clear why continuous improvement is important. If a process was improved five years ago, it most likely is not accurate anymore. As human nature tends to do as one has always done, it is difficult to bring about change without some guiding or action plan. Flaws in this process were only found because we were looking for them. We aimed to increase the reliability of care, as well as gain better quality, more capacity, operational reliability and quicker service. We can say we succeed in all other aims except quicker service.

One reason to achieve such practical results was that the Lean team adopted Lean philosophy deeply. The team did not just implement Lean tools, but had great discussions, and goals were clear all the way. Lean did not become a goal itself, but it worked as it should as a tool to achieve set goals. Compared to other Lean studies in medical imaging context, we focused more on patient safety, the most of other studies were more focused on increasing efficiency and throughput. Sure evidence of this Lean culture adaption is that even the actual project was already finished continuous improvement holds strong.

Another key factor to get successful results was an enthusiastic Lean team. All members were open for improvements and discussions were multidimensional. The group benefitted from multi professional background and had a wider scope for that reason. If the team would have only consisted of technicians, we might have got more limited results. Achieving results and improvements required no financial investment from department, only working hours were sacrificed. Altogether the Lean team worked



roughly 58 man-hours during this development project. This included meetings and 5S implementation. Time and effort was reasonable compared to the advantages gained.

This project showed that there are much things that can be improved even in small workflows. Some results may be generalized for other nuclear medicine departments, like breast stickers or information field visibility. Based on this study someone could generalize a checklist for sentinel node gamma imaging, like a help guide for all nuclear medicine departments. Best practices could include stickers, guides, referrals etc. 5S is also a tool that is adoptable everywhere in Medical imaging, or any other healthcare department. What we can learn is that most likely these Lean projects should be performed for more examinations and all examination rooms.

Achieved results were implemented, but new improvement needs have already been found. More guides are coming during autumn for other studies as well. Even before this project and without knowledge on the Lean methodology, we had already followed two important rules. Firstly each patient gets an individual appointment time for injection as well as for imaging. Lean highlights that we should aim to do one flow unit at a time to be efficient. That rule matches perfectly the sentinel node gamma imaging workflow. The other thing we had well aligned with Lean management was that repeated examinations due to poor execution mainly does not exist in this examination. Some additional pictures may be needed, but not retake the whole study.

The Lean methodology highlights the need for continuous improvement and always aims for better quality service. Lean has transformed from tools to a cultural change and improvement ideas arise systematically at the department. After this Lean project 5S has been implemented in other examination rooms as well. Also our storage rooms got under 5S recently. Based on that maybe 5S is the easiest tool and result to implement anywhere. This awareness of continuous learning is the biggest result for the department.

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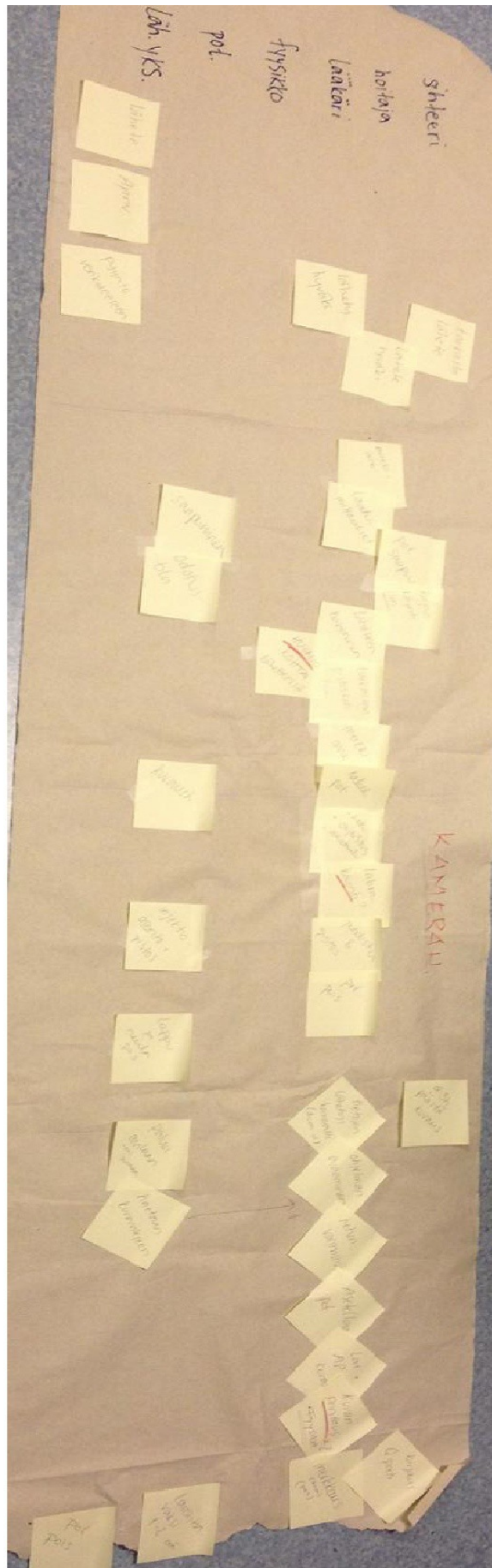
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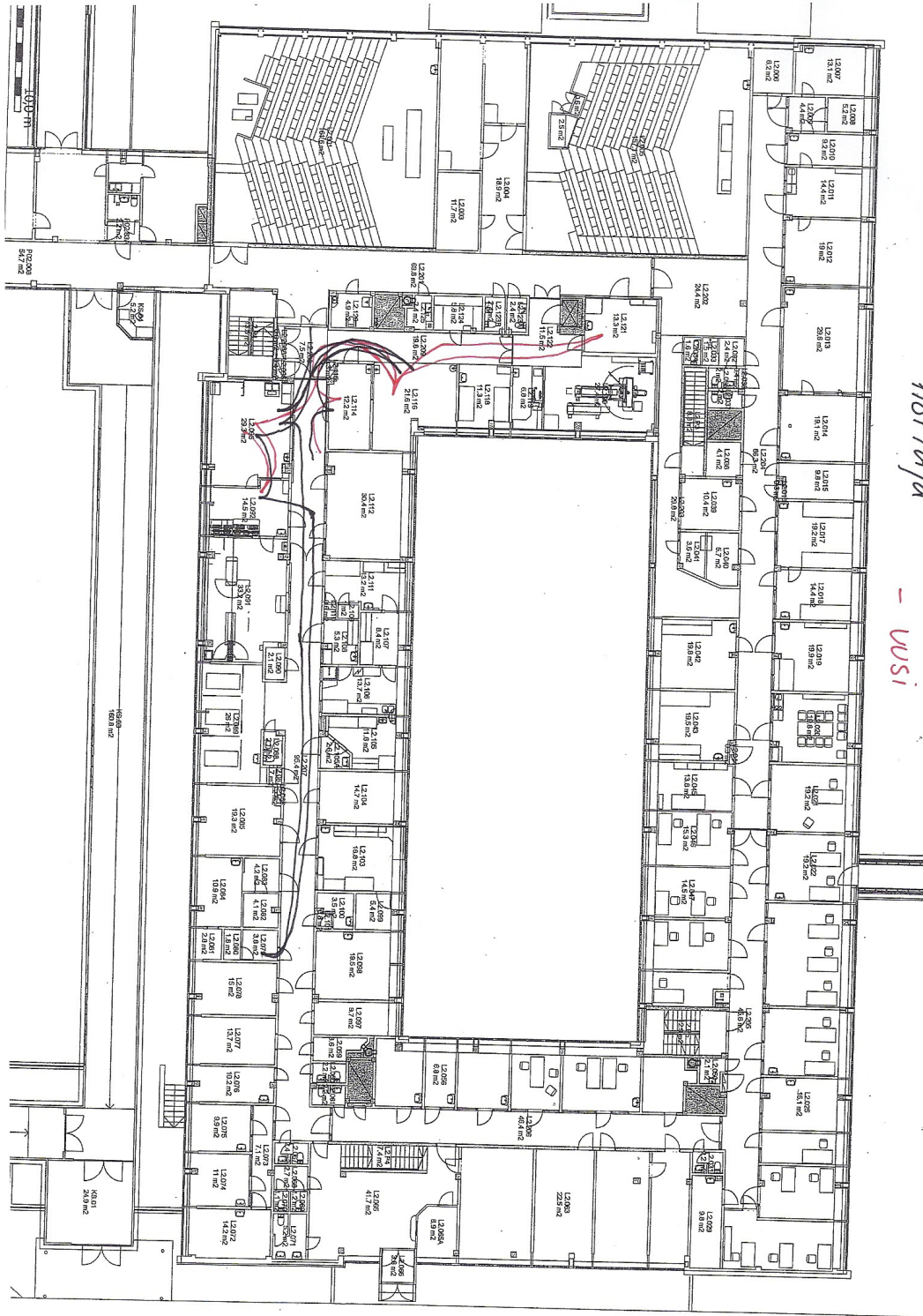
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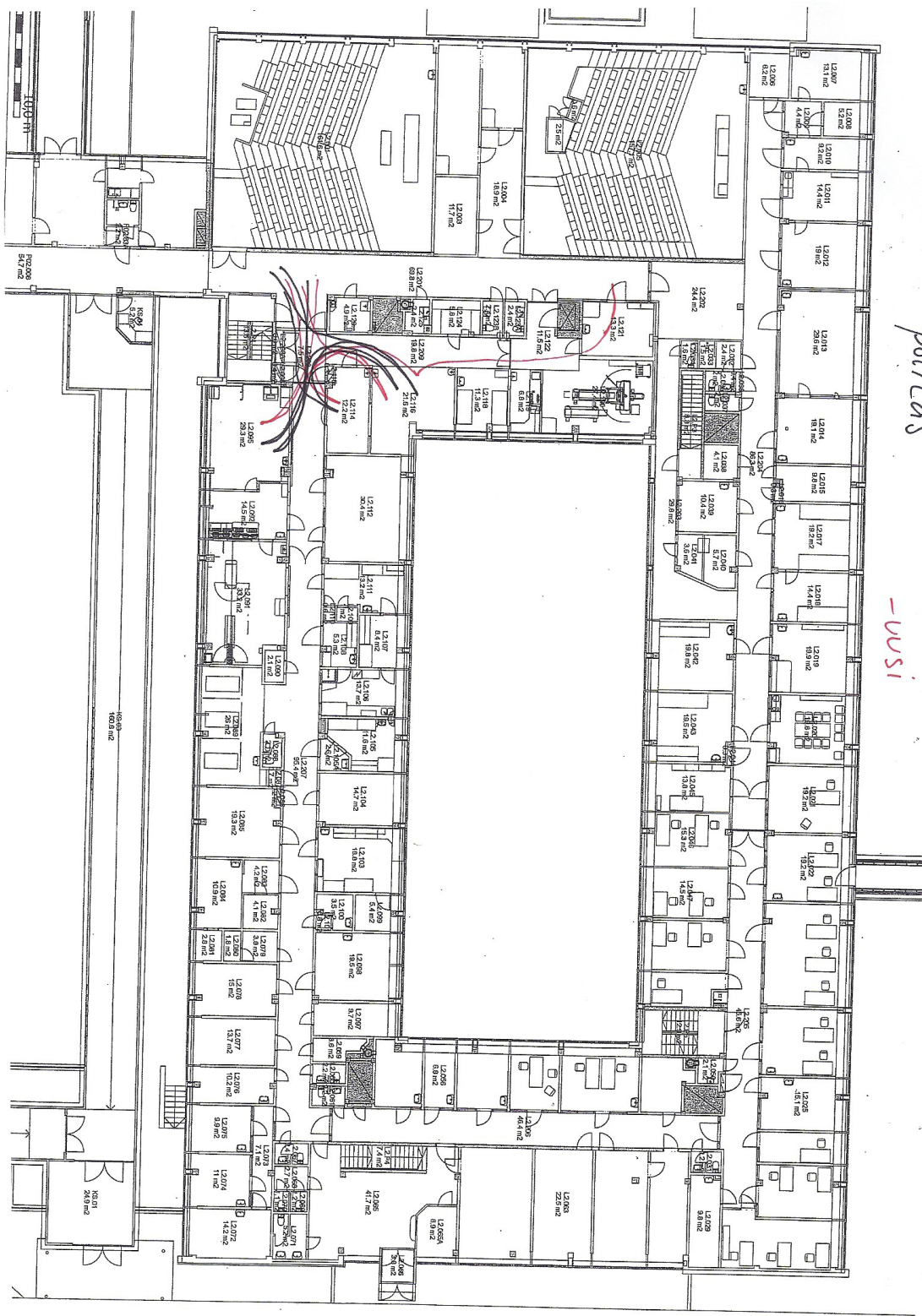
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hoitaja  
- vanha  
- uusi







Meilahti isotooppi

VARTIJAIMUSOLMUKKEITTEN PISTÄMINEN / Sorjo Mätzke

28.5.2014

Pistos ja aktiivisuus, volyymi	<p>Varovainen pistos ihon sisään (ic), neulaa poistettaessa suojaa tufferilla, ei saa painaa</p> <p><b>60 MBq 0,1 – 0,2 ml</b> volyymissa potilaaseen</p> <p><b>2.6.2014 lähtien, kahden viikon ajan testataan.</b> Jos 60 MBq ei toimi, palataan 80 MBq.</p> <p>Ruiskuun vedetään nestekerroksen päälle <b>ilmakupla</b>, jolloin ruiskujäämä vain n. 15MBq eli jos ruiskuun vetää 75-80 MBq – 15MBq= 60-65 MBq</p>
Areola Jyvä	<p>Areolan alle ei pistetä, vaan ihoon (ic) areolan kainalon puoleiselle reunalle.</p> <p>Jyvän kohtaan ei yleensä pistetä ellei erikseen pyydetä.</p>
Kuvaus	1- 4h injektiosta
Merkkaus	<p>Merkataan kaikki näytöllä näkyvät imusolmukkeet, myös parasternaaliset.</p> <p>Vahvoihin ruksi <b>+</b>, heikkoihin piste ..</p>
Lisäinjektio	60MBq. (Esim arven toiselle puolelle)

**TULOSTUSOHJE**Sivu: 1/1  
Versio: 1.0Laatija: H. Lähdeniemi  
Tarkastaja: J. Rintamäki**Klininen fysiologia ja isotooppilääketiede**  
**Meilahden isotooppiyksikkö**

Hyväksyjä: A.Loimaala

Pvm: 140514

**ADAC FORTE työlista****QPati** Kirjaa ensin jokaisesta potilaasta käyntitieto**Dicom Worklist** Avaa Dicom worklist- ohjelma työpöydältäkäyttäjänimi: pegasys  
salasana: worklist

(jos laitat ruksin kohtaan muista salasana, sitä ei tarvitse syöttää jatkossa)

Valitse OK

Valitse Procedure Date: today (päivämäärän lisäksi)

Paina Proceed

Valitse hiiren vasemmalla painikkeella Ctrl- pohjassa kuvattavat potilaat

Valitse Insert into Pegasys

Valitse Insert

New Query- painike palauttaa takaisin työlistan aloitussivulle.

**ADAC**Etsi potilas Adac työlistalta kirjoittamalla sukunimen 3 ensimmäistä kirjainta ja \*  
(esim. NIE\*)

Ääkkösten tilalle tulee \_ (Esim. L\_H\*)

Jos tietoa ei löydy voi etsiä myös sukunimen 2 tai 4 ensimmäisellä kirjaimella.

**Manuaalinen  
lisääminen**

Jos potilastietoa ei löydy kameranalta, lisää potilastiedot manuaalisesti. Kuvia EI lähetetä PACS:iin vaan viedään fyysikoille yhdistettäväksi.

**TULOSTUSOHJE**Sivu: 1/1  
Versio: 1.0Laatija: H. Lähdeniemi  
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Hyväksyjä: A.Loimaala

Pvm: 140514

**VARTIJAIMUSOLMUKKEEN GAMMAKUVAUKSEN TULOSTUS HERMES**

- Tulostus** Valitse Static- tyyppiset kuvat hiiren vasemmalla painikkeella ctrl-pohjassa järjestyksessä AP ja sitten SIVU.
- Avaa Display & Scale  
Valitse kuvanäkymä kuvien määrän mukaan (2 tai 4-jako)
- Valitse Predefined  
--> Meilahti-2krs- Vartijaimusolmuke  
tarkasta vas. alareunasta että käytössä on CT 15 värikartta
- Klikkaa hiiren oikealla painikkeella injektiokohtaa.  
Hae kuvalle sopivaa kontrastia ja tummuutta klikkaamalla hiiren oikealla eri kohtiin, lähelle injektiokohdan reunaa.  
Kun olet saanut hyvän kontrastin, voit vielä hienosäätää tarvittaessa liikuttamalla Fine Adjust UL- palkkia hiiren vasemmalla painikkeella.
- Paina Show Results  
Raahaa avautuva ruutu reunasta keskelle.
- Valitse Annotate  
Lisää puolenmerkit klikkaamalla hiiren vasemmalle kuvan alapuolella tyhjää kohtaa. Aukeavaan ruutuun voi kirjoittaa puolenmerkit. Tee sama AP ja SIVU kuville.
- Paina Print Results  
Valitse alavetovalikosta Imageprint (tekee PACS:n tallennettavan kuvan), valitse copies 1.  
Paina Print.
- Valitse uudelleen alavetovalikosta MEI\_2krs\_PET ja copies 2 kappaletta.  
Paina Print.
- Voit sulkea kuvat Dismiss painikkeesta.
- PACS Arkistointi** Etsi potilas Hermeksestä ja valitse Print- tiedosto.  
Raahaa se PACS -Meilahti2 - arkistoon hiiren vasen painike pohjassa.  
Kuittaa onnistunut lähetys, Success  kuvakkeesta.



## Kuvausohje

Sivu: 1/3

Versio: 1.1

Laatija: M.Airut  
Tarkastaja: H.LähdeniemiKliininen fysiologia ja isotooppilääketiede  
Meilahden isotooppiyksikkö

Hyväksyjä: A.Loimaala

Pvm: 210814

## VARTIJAIMUSOLMUKKEEN GAMMAKUVAUS, RINTA

Laitteet / välineet	ADAC Forte -gammakamera <sup>57</sup> Co-tasolähde, <sup>57</sup> Co-kynä, musta vedenkestävä tussi AP-merkintöihin.
Merkkiaine ja aktiivisuus	<sup>99m</sup> Tc-Nanocoll 60 MBq (ruiskuun vedetään ilmakupla, joka tyhjentää ruiskun injisoitaessa) Tilavuus enintään 0,2ml. Uusintainjektio 60MBq. Keskimääräinen efektiivinen annos: 1,7 mSv.
Kollimaattori	LEHR
Injektio	<sup>99m</sup> Tc-Nanocoll vedetään 1 ml:n kierrekantaiseen ruiskuun. Ruiskun kanta täytetään kokonaan ja varmistetaan, että neula (25G x 1") on tiukasti kiinni ruiskussa.  Hoitaja pistää kuvausaineen intracutaanisti 1 – 4 h ennen kuvausta isotooppi-osastolla. Tarvittaessa uusintainjektion antaa kuvaava hoitaja.
Kuvaus	Kuvaaminen voidaan aloittaa 1 - 4 h injektioista.  Valitse ohjelma: <b>Vartijaimusolmuke</b> Potilas on selinmakuulla tutkimussängyllä, pää edellä. Rutiinisti kuvataan AP- ja sivuprojektiot. Jos AP-kuvassa ei tule näkyviin sentinellejä tai sentinellit näkyvät vain parasternaalisti, otetaan lisäksi AP-vetokuva, jossa potilas vetää rintaa alamediaalisuuntaan.

## 1. kuva LAT SIN / LAT DEX

Potilaan leikattavan puolen käsi on kuvauksen aikana ojennettuna ylös. Kuvaus käynnistetään. Aseta kobolttitaso vastakkaisen kameran eteen. Lähteen voi asettaa ja myös poistaa kesken kuvauksen heti, kun kuvassa potilaan ääriviivat erottuvat selkeästi taustalevyä vasten.

## 2. kuva ANT

Potilaan leikattavan puolen käsi on kuvauksen aikana ojennettuna suoraan sivulle (90°). Kuvaus käynnistetään. Aseta kobolttitaso etukuvassa alakameran kollimaattorin päälle. Lähteen voi asettaa ja myös poistaa kesken kuvauksen heti, kun kuvassa potilaan ääriviivat erottuvat selkeästi taustalevyä vasten. AP-kuvaan merkitään löytyneet sentinellit mustalla pesunkestävällä tussilla. **Voimakkaasti kuvaantuvat sentinellit merkitään rastilla ja hennot pisteellä.**

## 3. kuva ANT VETO

Potilaan leikattavan puolen käsi on kuvauksen aikana ojennettuna suoraan sivulle. Potilas ottaa vastakkaisen puolen kädellä leikattavasta rinnasta tukevasti kiinni ja vetää rintaa alaviistoon, pistoskohta siirtyy kainalon päältä pois-päin. Kuvaus käynnistetään. Aseta kobolttitaso etukuvassa alakameran kollimaattorin päälle. Lähteen voi asettaa ja myös poistaa kesken kuvauksen heti, kun kuvassa potilaan ääriviivat erottuvat selkeästi taustalevyä vasten. Löytyneitä imusolmuketta ei merkitä ihoon.

Tallennusosoite:	R:\7440_Lablaatu\lablaatu_kl_fysiol_ ja_isotooppi\Meilahti_isotooppi\Arkisto\Word-arkisto\03_Tutkimusohjeet\Vartijaimusolmukkeen_paikant_gammak\Kuvaus\Forte_Vartija-rinta.doc
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## KVAUSOHJE

Sivu: 2/3

Versio: 1.1

Laatija: M.Airut  
Tarkastaja: H.Lähdeniemi

**Kliininen fysiologia ja isotooppilääketiede**  
**Meilahden isotooppiyksikkö**

Hyväksyjä: A.Loimaala

Pvm: 210814

Jos kuvissa ei nähdä kainaloimusolmukkeita tai sentinell näkyy heikosti, annetaan potilaalle vielä uusi injektio. Uusintainjektio annetaan samassa linjassa kainalon suuntaan 1 – 1 ½ cm lateraalisemmin kuin ensimmäinen injektio. Jos potilaalle on laitettu jyvä, neuvottele uusintainjektion kohdasta lääkärin kanssa. Uutta kuvausta ei enää tehdä. Potilasta ohjeistetaan, ettei merkkejä saa pestä pois.

**Tulostus** Kuvat siirtyvät kameralta ensin Philips IntelliSpace Portal ohjelmaan. Kuvat tulostetaan Portalissa erillisen ohjeen mukaan.

❖ Portal password adac2

Potilaalle tulostetaan paperikuva mukaan erillisen ohjeen mukaan. Lausuvalla lääkärille tulostetaan oma paperikuva, johon on nuolilla merkitty, mitkä sentinellit iholle on merkitty.

**Arkistointi** Kaikki tiedostot lähetetään Hermekseen ja Print-tiedostot lähetetään Portalista HUSPACS-arkistoon.

**Liittyvät ohjeet** Tulostusohje, kuvausparametrit ohessa

**Jakelu** Forten kuvausohjekansiot 2. krs

## Kuvausparametrit:

Protocol Information		Pscope / Spectrum	
Protocol Name:	Vartijaimusolmuke	Step Name:	ANT
		Step Type:	Static
<b>Detector/Imaging</b>		<b>Orientation</b>	
Detector(s):	1	Position:	Supine
Detector 1:	AP	Orientation:	Head First
Detector 2:	AP		
View ID:	TC-99m_INTR	<b>Save Location</b>	
Flood:	NONE	Save Location:	Pegasys
Collimator ID:	LEHR		
Zoom:	1 x (Full Field)		
Matrix Size:	256 x 256		
<b>Isotope</b>			
Detector 1:	TC 99m / C...	Detector 2:	TC 99m / C...
<b>Stop Criteria</b>			
Stop Control: <input type="checkbox"/> Link detectors			
Total Time:	300	300	sec
Total KCounts:			
Saturation Level:	32,767	32,767	
Saturation Behavior:	Continue	Continue	

Protocol Step: ANT ja ANT VETO

Tallennusosoite:	R:\7440_Lablaatu\lablaatu_kl_fysiol_ja_isotooppi\Meilahti_isotooppi\Arkisto\Word-arkisto\03_Tutkimusohjeet\Vartijaimusolmukkeen_paikant_gammak\Kuvaus\Forte_Vartija-rinta.doc
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