The Application of Lean Thinking to the Care of Patients With Bone and Brain Metastasis With Radiation Therapy

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Abstract

Purpose: Patients with bone and brain metastases are among the most symptomatic nonemergency patients treated by radiation oncologists. Treatment should begin as soon as possible after the request is generated. We tested the hypothesis that the operational improvement method based on lean thinking could help streamline the treatment of our patients referred for bone and brain metastases.

Methods: University of Michigan Health System has adopted lean thinking as a consistent approach to quality and process improvement. We applied the principles and tools of lean thinking, especially value as defined by the customer, value stream mapping processes, and one piece flow, to improve the process of delivering care to patients referred for bone or brain metastases.

Results and Conclusion: The initial evaluation of the process revealed that it was rather chaotic and highly variable. Implementation of the lean thinking principles permitted us to improve the process by cutting the number of individual steps to begin treatment from 27 to 16 and minimize variability by applying standardization. After an initial learning period, the percentage of new patients with brain or bone metastases receiving consultation, simulation, and treatment within the same day rose from 43% to nearly 95%. By implementing the ideas of lean thinking, we improved the delivery of clinical care for our patients with bone or brain metastases. We believe these principles can be applied to much of the care administered throughout our and other health care delivery areas.

Introduction

Bone and brain metastases are common manifestations of progressing malignancies. The main goals in administering radiation therapy for patients with these conditions are pain relief, preservation of the bone's function and integrity in bone metastases, and control of neurological symptoms in patients with brain metastases. Because early palliative therapy with radiation can provide rapid relief of symptoms in patients with bone or brain metastases,¹⁻³ timeliness of evaluation, simulation, and start of actual treatment is an important goal for the patient. Examination of the routine practice of care at our medical center revealed that only a minority of such patients were evaluated and started on their palliative treatments within the same day; thus we felt there was a tremendous opportunity to improve the delivery of care for these patients. Furthermore, as a significant number of our patient population resides outside of the southeast Michigan region, and must travel long distances to receive care at our facility, there was an opportunity to accommodate patients' desire to decrease the number of visits to start their therapy.

In an effort to deliver this type of timely, quality care, the Radiation Oncology Department at the University of Michigan turned to the process improvement ideas of lean thinking. The University of Michigan Health System's (UMHS) adaptation of lean thinking as a consistent approach to quality and process improvement is also called the Michigan quality system (MQS).⁴ Lean thinking is a management philosophy developed from the manufacturing industry, initially pioneered and championed by Toyota Motor Corporation.⁵ Taiichi Ohno, who is regarded as the founding father of Toyota's lean produc-

tion, has described the principle objective as "to deliver the maximum value to the customer while consuming the fewest resources by eliminating waste and reducing lead time."⁶ Lean production has spread rapidly from the manufacturing industry to service industries such as banking, insurance, hotel management, and some health care organizations.⁷⁻⁹

With the goal of improving the delivery of treatments to patients with bone and brain metastases in a timely manner, we set about improving the process of care using the tools and philosophy of lean thinking. After the improvement activities, we assessed our success in achieving our goal of evaluation, simulation, and treatment within a single day's visit.

Methods

In July 2005, the Radiation Oncology Department at the University of Michigan commissioned a process improvement team to implement a lean project to improve patient care access and reduce excess work in providing palliative radiation therapy to patients referred for bone or brain metastases. Each year, the Department of Radiation Oncology's University of Michigan Hospital site (which is the largest facility served by the department) sees 1,600 new cases of patients seeking radiation therapy as a modality of treatment, approximately 15% of whom have bone or brain metastases.

The choice of this patient group was made by departmental leadership based on several advantages: patients with bone and brain metastases are typically the most symptomatic patients in the department (aside from oncologic emergencies); the treat-

ment planning and delivery procedures have a standard which is well accepted by the department faculty and staff; and the input information necessary to initiate same day therapy would almost always be available, as nearly 100% of such referrals are from other University of Michigan physicians.

We first established a team representative for all the first-line service providers: clerical staff, attending and resident physicians, simulation therapists, radiation therapists, nursing staff, physics and other administrative and support staff. The team then developed a current state value stream map (CSVSM) for the treatment of bone and brain metastases. A CSVSM is a detailed flowchart that reveals all the actions and processes required to deliver a service to a customer. The greatest benefit of creating a value stream map as a lean thinking tool is that it allows the whole team to visualize all the steps involved in the work, and to then improve the whole process, and not just optimize individual parts.¹⁰ The CSVSM permits the determination of “process time” (the actual time it takes to complete an activity), the “total lead time” (the total elapsed time associated with completing an activity), “first time quality” (the probability that a product (or the patient) will go through all individual process steps without encountering a quality-related problem),¹¹ and the “process cycle efficiency” (process time divided by the total lead time—a measure of what percentage of time is spent in value added activity). Any process with a cycle efficiency of less than 10% indicates that there is significant non-value added activity, or waste.¹² Waste is defined as “any human activity which absorbs resources but creates no value (from the perspective of the customer).”¹³

In the next phase, we designed a future state value stream map (FSVSM), an often radically different series of process steps that allows the delivery of value to the customer faster, with fewer defects, using fewer resources. A FSVSM is constructed by determining if any of the steps in the process can be done with less waste, or can be eliminated altogether.¹⁰ The next step was to create a detailed work plan for implementing the FSVSM—to make that proposed process a reality. In implementing the FSVSM, members of our team were assigned specific tasks with timelines to drive the flow of the process with optimal efficiency.

One of the first improvements was to revise the process for handling the call-in, dispatch, and scheduling procedure for evaluation, simulation, and treatment. To do this, we developed a standard method of scheduling and preparing all the inputs to this process (medical documents, imaging studies/reports, physician notes, insurance information) as required by the physicians and billing department. The clerical staff forwarded all referral calls to the radiation oncology schedulers. Assistant personnel worked with the on-call house staff to set an appointment time and communicate to the chief therapist and nursing staff that a new patient needed to start treatment that day. Billing was notified, and the chart, including medical documents and imaging studies, was prepared in a standard format as directed by the physician group. These guidelines were out-

Table 1. Scheduling Consultations

The Following Information Is Needed for Scheduling a Consultation

Patient name and registration number: if none exists, a new one is to be created

Patient information needed: name, address, social security number, gender, phone number, insurance coverage, and primary care physician

Referring physician information: name, unique physician identity number, clinic name, office address, phone number, and contact name

Diagnosis (determines whom the patient will see in the radiation oncology department)

All information should be typed into procedure box in scheduling package

The requesting clinic is asked to fax a consultation sheet to the radiation oncology department; the caller is put on hold while the list of requirements is faxed to the given number

List of requirements

Office notes

Pathology reports

Radiology reports (written/hard copy)

Surgery reports

Laboratory results

If treated before: end of treatment summary

Port films

If all the patient information has been brought to the university in a different clinic we request that it is forwarded to our department

The caller is then given directions to the university and location of the department

The patient is mailed an itinerary and map

The patient is called the evening before as a reminder of their appointment

Inserted into the chart are (when available): consultation sheet/referral, written radiology reports, outside CDs, all of the previously above mentioned information, a patient face sheet (demographics) and upon simulation, a picture of the patient*

* There are variances to this such as: if patient is a self referral, a consultation sheet does not exist. When a last minute add-on is scheduled we usually do not receive the information needed for a regular scheduled appointment.

lined and explained to the clerical staff in a work sheet to improve the flow of work (Tables 1 and 2).

Results

Evaluation of the process before the initiation of this lean project revealed that treating patients with bone and brain metastases was a rather chaotic process that required 27 separate steps to evaluate, simulate, and start treatment (Fig 1, online-only data supplement). It also revealed that only 43% of the patients in the prior 6 months leading up to this project went through the entire series of steps required within a single day of visit. Furthermore, although the process time averaged about

Table 2. Standardization of Consultations, Simulation, and Start Same Day

All referring clinics phone the radiation oncology schedulers
Radiation oncology staff bring a simulation activity document and a billing form to nursing desk assistant (clerks) for scheduling of brain and bone metastasis patients; the clerk pages the on-call resident with the information and logs the call
The assistant informs the chief therapist and nursing staff about the add-on case
The assistant schedules the consultation (if needed) along with computed tomography simulation and start for the same day
The assistant notifies billing at 7-5045 of the add-on case
The assistant creates chart, and collects all standard inputs (see: standard input sheet)
Call radiology department 6-4516
Retrieve documents from Careweb*
If outside referral retrieve documents from patient or physician

* The University of Michigan Health System electronic health record.

290 minutes, patients often waited up to 1 week before they had their treatments initiated (process time of 290 minutes divided by a lead time of up to 10,000 minutes, or a process cycle efficiency of as low as 3%). This significant delay was due to the long wait times patients experienced while their paperwork or medical records were being collected or reviewed by the clinical service team. Importantly, we estimated that only 0.2% of the patients referred for the palliative bone or brain radiation went through the entire process from referral to start of therapy without the need for some sort of rework (first time quality in Fig 1).

Our future state map revealed that the number of steps needed to initiate radiation therapy could be reduced to 16 steps; the process time could remain stable at 225 minutes, while the wait time cut down to nearly 1 day; and the potential to improve first time quality to 100% (Fig 2, online-only data supplement).

We are encouraged by the results of implementing the changes planned through the future state. Compared with a baseline measurement before the start of this MQS project, where only 43% of the patients could have their evaluation, simulation, and treatment initiated with a single visit, 94% of the patients now go through this process with a single visit, approaching our goal of 95% (Table 3).

Another achievement that came out of this project was to decrease the number of visits required to be evaluated and treatment started. Previously, many of the patients made two or more visits to the clinic site to go through a consultation visit, followed by a simulation visit, which would then be followed by yet another visit to start therapy.

Discussion

In this study, we have found that while we were providing quality radiation therapy for our patients with bone and brain

metastases, we were not able to meet their need of receiving timely and efficient evaluation, simulation, and therapy initiation. In addition, there was often poor first time quality because we did not always have the information we needed to carry out our tasks, and our work was not standardized. Through the use of the lean thinking process improvement model, we have redesigned our process, and have been able to decrease the total number of steps required to treat this patient population, decrease the number of visits required to start their therapy, and accommodate nearly all of our patients to go through the multistep process within a single day, while decreasing our own work.

The application of lean thinking in the manufacturing sector has been highly successful and reproducible in different companies. Corporations such as Toyota, Wiremold, Pratt & Whitney, and Showa Manufacturing utilized the principles and tools of lean thinking to revolutionize the way they operated their businesses.^{5,13} We found that our current system of operation in delivering radiation therapy to patients was a fragmented process which required a shift in how we thought about the flow of patient care delivery. This sort of self discovery is not an uncommon phenomenon as one engages in a lean thinking project. As we focused to improve the flow of care, our goal was to build quality into the process so that we could strive to do the work correctly the first time. This concept of built-in quality assures that errors are not passed on. Furthermore, if an error did occur, it would be identified early in the process so that information can be used to correct the error, before causing further and exponential problems downstream in the process. Health care has traditionally used a process of inspecting the work as it gets passed on to the next step of the process. This method of check system could lead to the need for workarounds, where a quick fix would be needed on the spot; or rework by the individual that found the problem or individual(s) that performed the previous steps. Lean thinking encourages each team member to monitor and develop ideas to improve the flow of process, so that everyone focuses continuously on the goal of eliminating waste.^{14,15} This may be a novel idea to the health care sector, but if implemented in the right way, can dramatically change the way we provide care, with greater efficiencies and less delay. The procedural list and check-points utilized in our study (Table 1) is an example of how we tried to achieve improved patient flow by building quality into our process.

Standardization, a key lean tool, helped improve our ability to provide care. Without standardization, there is likely to be great variability in how work is done, and lead to rework and reduce the quality of care provided. We decided that all the necessary information needed to be available for the physicians and therapists early in the process with a high degree of accuracy to improve quality and efficiency. To do this, we standardized the way information was requested and collected (Table 4). When accurate information is not available the process of caring for a patient is simply halted and leads to rework.

Table 3. Results Before and After Lean Production Initiative in Radiation Therapy for Patients With Bone and Brain Metastases

Metric	Baseline	Post-Implementation
Patients able to undergo evaluation, simulation, and initial radiation treatment within the same work day (regardless of whether these activities occurred on the same day as the initial consultation call or on a different day), %	43	94
No. of process steps	27	16

Continuous improvement is to create an environment in which all workers continuously seek and implement innovative ideas, based on the customer's requirements, and built on the previous level of standardization.⁴ As we made the initial changes, it became evident that the clerical staff, who often received the first call from referring clinicians, needed education on medical terminology and scheduling procedures. For example, referring clinicians who referred to their patients as having a bone lesion were not being scheduled into a same day consult appointment. This may seem trivial at first glance; however, to those unfamiliar with the terminology, it can be confusing and lead to process errors. As our staff became aware that this was the same as a bone metastases, patients were appropriately routed onto the bone and brain metastases appointment times.

As with any new initiative, there are challenges and barriers that need to be addressed. When individuals are told that the roots of lean thinking comes from the automobile manufacturing industry, an argument is often made that people are not automobiles, and thus each require special, individualized, and customized attention. As we learned about the principles of lean thinking, we gradually understood that there is a great amount of inefficiency in the processes of delivering clinical care that could benefit greatly from redesign with a process mentality around the needs of the customer.

This study has several limitations. First, this study was done in a single health system, and more specifically within a single clinic site, thus the specific application and results may not be generalizable to other institutions and sites. For example, other organizations may have different baseline metrics and a different set of current process flows, which would lead to other target implementation ideas. Second, we have reported on our ability to improve the efficiency of delivering this type of radiation therapy care, and an ad hoc analysis did not reveal any reduction in the quality of care provided to our patients for this service or other services provided by the Department of Radiation Oncology. However, we did not formally assess quality metrics related to this process nor its potential effects on the other services provided by our department. Third, our study evaluated the process and the opportunity to improve on the operational efficiencies to provide timely and quality radiation therapy with the perspective of providing this service to our patients as the customers. Referring physicians are also customers to this process and we did not formally measure their satisfaction (informal evaluation has, not surprisingly, been

very positive). Lastly, within the limits of this brief report, we are not able to provide a detailed account of lean thinking application for this project. Instead, we have chosen to report a few of the highlights of our journey and the major tools in applying lean thinking concepts within our department. For more detailed information, additional examples in

Table 4. Standardization of Work and Information Needed for Radiation Therapy

Standardized duties for clerks

- Radiation oncology schedulers receive requests by phone for treatment from all sources (referring clinics, radiation oncology physicians who may have received the initial consultation call)
- Communicate to the chief therapist and nursing staff that a consultation has been called in requiring same day attention
- Schedule the consultation, CT/simulation, and start for that day
- Notify billing
- Have the chart organized and include all the standard inputs required from radiation oncology physicians, simulation therapist, and physics and administration
- Call radiology to retrieve images
- Retrieve documents from our electronic health records system, or outside records if the referral was made from an outside physician

Standardized information required by physicians to perform the consultation*

- Office notes
- Operative reports
- Pathology reports
- Imaging reports and images
- Previous radiation records
- Demographic information

Standardized information the simulation therapist, and physicists and administration required to perform the CT/simulation

- Site diagram
- Field requirements
- Volumes to be contoured
- Physicians orders-positioning, contrast, markers, and critical structures
- Treatment directive

Abbreviation: CT, computed tomography.

* This became a written guideline that was easily accessed by the clerical staff to meet the requests of the physicians.

health care, and readings about lean thinking, readers are referred to the references.^{5,8,10,13,15-17}

Within the Department of Radiation Oncology at the University of Michigan, we have improved the way we deliver radiation therapy to our patients with bone and brain metastasis utilizing the principles and tools of lean thinking. We believe that this pilot study will continue to improve the way care is provided for this subgroup of patients; and as our department becomes more proficient with lean thinking, we will be able to implement these ideas and concepts in our everyday practice of delivering care. Although a limitation of this study was that it was done at a single clinic site in a large university-based practice, we believe there is a potential for these methodologies to be relevant for health care providers practicing in similar types of organizations. Often in large organizations, pathways for care evolve over time, rather than being designed. As long as the process is not overtly broken (ie, able to function with a moderate number of work-arounds and rework), few individuals think to reassess and improve the situation. By using lean thinking as a systematic approach, busy health care providers may be able to improve the process steps and deliver a more optimally designed clinical care.

Lean thinking emphasizes the need for continuous experimentation by the first-line workers to improve and standardize the work flow, a core concept established and advanced by Toyota

Motor Corporation.^{14,15,18,19} We will continue to monitor and improve this process of providing same day evaluation and treatment for bone and brain metastases; and we will apply the lean thinking ideas to other areas of our clinical care delivery service such as three-dimensional treatments, charge procedures and daily treatment flow. The real challenge is to go beyond the simple application of lean tools, which is what we do now, and to develop a lean culture of continuous questioning and improvement.

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The authors indicated no potential conflicts of interest.

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