Improving the safety of chemotherapy process by a risks management tool

Chemotherapy compounding in Oncology Center in Oujda (Morocco)

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Abstract

Objectives: Chemotherapy compounding is a main step of chemotherapy cancer process. This step is formed by many parts. A multidisciplinary team is assembled to define critical points and failures linked to this process and proposed different actions to secure them and improve chemotherapy cancer process.

Methodology: By a prospective analysis risks tool: the failure modes, effects, and criticality analysis (FMECA), anticancer drug process compounding was sequenced in many parts. During the brainstorming, different ideas expressed and were classified into an Ishikawa cause–effect diagram. The criticality indexes (CI) are calculated from occurrence, severity, and the detection probability.

Results: The sum of CIs of 18 identified failure modes was CI=3607 for the decentralized system and CI = 726 after the new organization of compounding process. The chemotherapy production step represents 37.17% (CI =1341) of all failures in the old process. The greatest risk reductions between the old and the new process concerned the risk of “Double check missing before delivery to the ward” by a factor reduction of 28.0). Among the CIs remaining superior to 100, there was one failure: ‘Typing error during prescription’ (CI = 144).

Conclusion: Modification of the chemotherapy-compounding process by centralization, training program, and implementation of procedures resulted in an important risk reduction as shown by risk analysis. Our study illustrates the usefulness of risk analysis methods in the healthcare system. A systematic use of risk analysis is needed to improve the safety of high-risk activities in healthcare processes.

Keywords: anticancer drug process, centralization organization, chemotherapy-compounding process, chemotherapy production, failure modes, effects, and criticality analysis, healthcare process, patient safety, risk management tool

Key messages

- Using a risk analysis method to evaluate a drug process.
- Based on CIs, FMECA measures the risks associated with the chemotherapy-compounding process.
- This study has identified major risks in our chemotherapy-compounding process.
- Chemotherapy-compounding centralization is an essential step for securing the care of patients with cancer.

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Introduction and context

Chemotherapy cancer process is a complex system.\textsuperscript{1,2} In general, three main steps form this process: prescribing, compounding, and administration.\textsuperscript{1,2} Many errors are made at the compounding step of chemotherapy process.\textsuperscript{3}

A safety of chemotherapy process is an important objective for oncology centers.\textsuperscript{1,2} To achieve this goal, permanent evaluation of the process must be carried out for a new possible organization, even if it is radical.\textsuperscript{2,3} There are several ways to evaluate the different risks associated with a process, but the prospective tools remain the most recommended.\textsuperscript{3} The failure modes, effects, and criticality analysis (FMECA) is a method which assesses this process. It identifies, classifies, defines, and prioritizes the major critical failure modes to improve the safety.\textsuperscript{3}

Objectives

In Oncology Center of Oujda, anticancer drugs compounding is made in two departments: ‘Medical Oncology Department’ and ‘Inpatients Department.’ Oncology Pharmacy Department has led and set up a risk management study to start a process to improve the compounding step of chemotherapy process.

Methodology

Mapping of the chemotherapy-compounding process

After chemotherapy protocol prescribing, chemotherapy-compounding step can be divided into many parts. First part is
'chemotherapy protocol validation,' second part is ‘packaging and labeling,’ third part is ‘the raw materials preparation,’ the fourth part is ‘the chemotherapy production,’ and the final part is ‘the control’ before delivery to the ward.[13] Once the process is determined, a prospective analysis of risks has been done.

Oujda is a town of the eastern region of Morocco.[8] It is a border town with Algeria with 494,252 population, according to the last general census of the population in 2014, making it, the 8th largest city in Morocco.[9] The city has a multidisciplinary regional hospital, a university hospital, and a regional oncology center.[8]

Oncology Center of Oujda is a hospital specialized in oncology, with 26 hospital beds. Every day, it receives an average of 50 patients scheduled for chemotherapy sessions. Anticancer drugs compounding is carried out at two departments: ‘Medical Oncology Department’ and ‘Inpatients Department.’ First one is equipped with a vertical laminar flow hood, and 3 nurses who reconstitute chemotherapy preparations. Every day, on average, ‘Medical Oncology Department’ carries out 95 chemotherapy preparations. In the other department, chemotherapy compounding is done by one nurse, without vertical laminar flow hood or isolator. Average anticancer drug compounding number for ‘hospitalization Department’ is 20 preparations per day.

Choice of the method used

Many studies have used the FMECA. FMECA is a quantitative prospective analysis method, which is able to detect failures and their consequences by the measurement of risks from criticality analysis bodies.[12]

It was developed by the United States Army as a military procedure, known as (procedures for performing a failure mode and effect analysis). Implementation of quality improvements based on this tool, really, began in the health field in 1990. Since then, the use of this method has spread, mainly in the field of hospital care and by hospital certification bodies.[12]

The National Center for Patient Safety in the United States adjusted this method to healthcare.[13]

Brainstorming

We have a multidisciplinary medical and paramedical team consisting of a competent pharmacist in risk management, two medical doctors: medical oncologist, a radiation therapist, and two nurses.

Six meetings were held and various people present interacted. At first, the goal was to identify the failures. In the second step, the team assigned them the values concerning gravity, occurrence, and nondetectability, thus resulting in a criticality score.[6,14]

Ishikawa diagram

The cause–effect diagram classifies the different ideas expressed during the brainstorming meetings and related it to all possible causes.[13]

Criticality indexes

CI can be calculated by three parameters: the occurrence, the severity, and the possibility of detecting the failure. Williams and Tally[14] have consensual quotes. The CI of each failure mode was calculated by multiplying the frequency, effect, detection scores (CI 1–810), and the results were summarized in a table.

Criticality is the product of three essential parameters, which are severity, occurrence, and detection. According to Williams and Tally,[14], the indexes of the occurrence are from 1 to 10. Index 1 has a probability of 1/10,000 and means ‘Remote, no known occurrence,’ and the index 10 shows a ‘Documented, almost certain error’ with a probability 1/10. Severity going from ‘the Slight annoyance’ (CI = 1) to ‘the terminal injury or death’ (CI = 9) and the detectability varies from ‘a very high system will always detect error’ CI = 1, to ‘Remote or detection not possible at any point within system’ CI = 9. CI varies from 1 to 810 and varies according to its score.[14]

Results

Failure modes definition

Our chemotherapy-compounding process was divided into fifth main parts: ‘chemotherapy protocol validation,’ ‘packaging and labeling,’ ‘The raw materials preparation,’ ‘chemotherapy production,’ and finally, the ‘control.’ Eighteen failure modes were identified during the brainstorming. All potential problems determined were summarized in Figure 1: Ishikawa cause–effect diagram for chemotherapy-compounding process in Oncology Center of Oujda.

Criticality analysis

Table 1 described the CIs calculated from the severity, defined frequency, and detection scores for the 18 failure modes. The total CI of compounding chemotherapy process was CI = 3607.
The sums of CI of step one to five were, respectively, 768, 878, 172, 1341, and 448.

After the new organization of the compounding chemotherapy process, the CI was reduced to \(\frac{446}{C_0}\) (\(\frac{446}{C_0}\) 58.07\%) in the first step.

In the second step, the CI was reduced by \(\frac{726}{C_0}\) (82.68\%), \(\frac{116}{C_0}\) (67.2\%) in the third step, \(\frac{1161}{C_0}\) (80.29\%) in the fourth step, and \(\frac{432}{C_0}\) (96.4\%) in the last step. The total CIs in the process were reduced by 2881 points (from CI = 3607 to CI = 726) (76.87\%). In addition, individual CIs were reduced by a mean factor of 5.9. The details of the variation of the CIs of the old and new processes are shown in Table 2.

For 17 out of 18 failure modes, the CI was smaller in new than the old process. The highest risk in the old chemotherapy-compounding process was in the fourth step ‘chemotherapy production’ with a CI=1341. This step is composed of five phases. The last phase of the chemotherapy production step ‘Chemical cross-contamination’ was the highest CI (448), the ‘Control’ step had, too, CI=448. The other failure modes with high CIs were ‘Poor production room quality’ (392), ‘Dose calculation error’ (288), ‘Dose calculation error’ (288), ‘Production error (Dose/product)’ (245), ‘Production error (Dose/product)’ (245), ‘Production error (Dose/product)’ (128), ‘Production error (Dose/product)’ (128). However, in the new process (final process), the most critical failure mode were ‘Typing error during prescription’ (144).

The greatest risk reductions between the old and the new process concerned the risk of ‘Double check missing before delivery to the ward’ (reduction by factor of 28.0), followed by ‘Poor chemotherapy production equipment’ by a factor reduction

| Table 1 |
|---|
| Failure modes and criticality indexes for the chemotherapy compounding process. |
| Chemotherapy-compounding process | Failure mode | Criticality index |
|---|---|---|
| Protocol validation | Prescription error (dose/route) | 84 |
| | Discordance between protocol and production sheet | 108 |
| | Patient identity error not detected | 144 |
| | Typing error during prescription | 144 |
| | Dose calculation error | 288 |
| Packaging and labeling | Error on the product label | 128 |
| | Poor packaging quality | 168 |
| | Illegible labeling | 288 |
| | No labeling | 294 |
| Raw materials preparation | Raw material unavailable | 28 |
| | Error in material preparation | 72 |
| | Expired drug | 72 |
| Chemotherapy production | Production error (dose/product) | 128 |
| | Wrong rules of asepsis | 128 |
| | Poor production equipment | 245 |
| | Poor production room quality | 392 |
| | Chemical cross-contamination | 448 |
| Control of preparation | Double-check missing before delivery to the ward | 448 |
| Sum | | 3607 |

| Table 2 |
|---|
| Failure modes and comparative criticality indexes for the old and new chemotherapy compounding process. |
| Chemotherapy-compounding process (phases 1–5) | Failure mode | Criticality index |
|---|---|---|
| Protocol validation | Prescription error (dose/route) | Old process 84 New process 28 Reduction factor (new/old) 3.0 |
| | Discordance between protocol and production sheet | Old process 108 New process 54 Reduction factor (new/old) 2.0 |
| | Patient identity error not detected | Old process 144 New process 48 Reduction factor (new/old) 3.0 |
| | Typing error during prescription | Old process 144 New process 144 Reduction factor (new/old) 1.0 |
| | Dose calculation error | Old process 288 New process 48 Reduction factor (new/old) 2.0 |
| Packaging and labeling | Error on the product label | Old process 128 New process 32 Reduction factor (new/old) 4.0 |
| | Poor packaging quality | Old process 168 New process 28 Reduction factor (new/old) 6.0 |
| | Illegible labeling | Old process 288 New process 64 Reduction factor (new/old) 4.5 |
| | No labeling | Old process 294 New process 28 Reduction factor (new/old) 10.5 |
| Raw materials preparation | Raw material unavailable | Old process 28 New process 8 Reduction factor (new/old) 3.5 |
| | Error in material preparation | Old process 72 New process 24 Reduction factor (new/old) 3.0 |
| | Expired drug | Old process 72 New process 24 Reduction factor (new/old) 3.0 |
| Chemotherapy Production | Production error (dose/product) | Old process 128 New process 32 Reduction factor (new/old) 4.0 |
| | Wrong rules of asepsis | Old process 128 New process 32 Reduction factor (new/old) 4.0 |
| | Poor production equipment | Old process 245 New process 20 Reduction factor (new/old) 12.25 |
| | Poor production room quality | Old process 392 New process 48 Reduction factor (new/old) 8.16 |
| | Chemical cross-contamination | Old process 448 New process 48 Reduction factor (new/old) 9.33 |
| Control | Double check missing before delivery to the ward | Old process 448 New process 16 Reduction factor (new/old) 28.0 |
| Sum | | Old process 3607 New process 726 Reduction factor (new/old) 5.9 |
of 12.25 and ‘Chemical cross-contamination’ (by a factor of 9.33), and ‘Poor production room quality’ (by a factor of 8.16). Figure 2 shows the evolution of the sum of CI between the old (decentralized system) and the new process (centralized system).

Data analysis

Analyses of the global impact concluded that the new process increased, significantly, the safety of patients by reorganizing the process and acting on complementary phases in the process. The largest improvement in safety was obtained by the centralization the chemotherapy compounding, followed by the control valuation by a double check before delivery to the ward and the administration of the chemotherapy product, and finally by the procedure implementation.

The examination of the residual risks in the final process has been done to evaluate their acceptability. Among the CIs remaining superior to 100, there was one failure: ‘Typing error during prescription (CI = 144). To reduce error during the writing of chemotherapy protocols, it was suggested to computerize this phase. The computerization improves the capacity of the pharmacist to detect prescription errors.[4]

Discussion

The FMECA is a proactive risk-analysis method used to reduce risks and to increase the safety of patients.[16] In our study, we performed an analysis to identify and to quantify the risk reduction. We hoped we had achieved by modifying our process and, above all, to identify residual risks that may require further actions. The FMECA method confirmed that reengineering the process of chemotherapy compounding had resulted in a significant risk reduction. There was a reduction in the CIs associated with almost all the failure modes with a total reduction of 76.87%.

This improvement in safety achieved with the new process was quantified with this analysis. Even though such a process obviously cannot avoid all errors, the risk for the patient to receive a chemotherapy contaminated by a chemical cross-contamination has been markedly reduced. Furthermore, the analysis identified and classified the residual risks, so the investigators had to decide whether to accept the determined level of risk or to further improve the safety of the process. In the current analysis, the most critical steps in the new process were considerably lower than in the old process, but other failure modes remained subject to further improvement. The risk of ‘Typing error during prescription’ in the protocol validation step became the most critical step in the new process.

Centralizing the compounding of cancer chemotherapies at the hospital pharmacy is the most common organizational measure taken by oncology centers to protect their healthcare workers from exposure.[4] Our study demonstrated that the centralization also markedly improves for patient’s safety, especially by increasing the detection of errors in prescribing protocols (validation by a pharmacist) and by limiting errors in chemotherapy compounding. However, with this single-process modification, some failure modes still have high CIs, and this should encourage hospitals to take additional measures. To reduce the global criticality at the prescription, a study of Bonnabry et al.[10] determined a reduction of the criticality at the prescription by introducing technologies at the prescription step, suggesting that the electronic devices could play an interesting complementary role to the centralization.

Improving the safety of the chemotherapy-compounding process requires other important approaches such as a training program for chemotherapy manipulators (pharmacy technicians) to respect good manufacturing practices,[18] a reduction of local procedures,[21] In addition to computerization of chemotherapy protocols, the implementation of new accreditation regulations for oncology hospitals[17] is also the main actions which can increase risks in chemotherapy-compounding process.[19]

The major interests of FMECA are its simplicity and the quantitative evaluation it allows by combining three complementary factors: likelihood of occurrence, severity, and detectability. It helps identifying the top critical events, which are very helpful to decide and prioritize actions that are to be taken. Moreover, the active discussions necessary to find consensual quotations contribute to the development of a very clear and shared vision of the process organization, taking into account all the different perspectives.

The limit of failure mode and critical analysis is the unavoidable subjectivity of the failure selection and the determination of the CIs. To reduce this subjectivity, the team...
must be large and the quotations must be consensual to guarantee objectivity.[20]

Conclusion
A prospective analysis FMECA was able to show the different risks surrounding the chemotherapy-compounding process. It allowed to review the whole process and to have coherence in its creation, its follow-up, and its improvement. Depending on the means, and the critical functions, all the proposed actions will be made to improve the chemotherapy-compounding process. On the other side, our study showed the role of oncology pharmacy department to improve the medical care for the cancer patient.

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