Patient satisfaction survey on portable infusion pumps for colorectal cancer chemotherapy: hard-shelled or soft-shelled?

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Research Article

Keywords: colorectal cancer, chemotherapy, infusion pump, elastomeric infusion pump, portable infusion pump, patient preference
Abstract

Background

Elastomeric infusion pumps are widely used in colorectal cancer chemotherapy. However, no studies have yet investigated patient preferences regarding different infusion pump types.

Methods

Twenty patients with unresectable colorectal cancer undergoing chemotherapy were initially treated with a portable hard-shelled continuous infusion pump, followed by a soft-shelled continuous infusion pump. The respondents used a numerical rating scale (0–10) to rate their comfort when using each pump, their ease of carrying it, the pump size and shape, its weight, their ease of reading its memory, and their overall satisfaction with it. They were then asked which pump they would ultimately prefer.

Results

In terms of comfort, significantly higher user satisfaction was reported for the soft-shelled pump during the daytime and when going out (P < 0.001, P < 0.001). For pump portability, size, shape, and weight, the soft-shelled type also outperformed the hard-shelled one (P < 0.001, P = 0.0011, P < 0.001). However, the hard-shelled pump scored significantly better in terms of ease of viewing memory (P < 0.001). Overall satisfaction was significantly higher for the soft-shelled pump than the hard-shelled type (p = 0.0095). Finally, 13 patients (65%) indicated that they would prefer a soft-shelled pump for their next treatment, while only one patient (5%) preferred a hard-shelled alternative. A preference for soft-shelled pump was observed, particularly in female patients and those with body mass index of < 22 kg/m².

Conclusion

Selection portable elastomeric infusion pumps that consider the preferences of patients with colorectal cancer may help improve their quality of life.

Introduction

The FOLFOX and FOLFIRI chemotherapy regimens for treating colorectal cancer require 46-hour continuous intravenous (IV) infusion of 5-fluorouracil (5-FU), so portable disposable pumps have been developed to provide these treatments on an outpatient basis [1, 2]. The use of portable pumps for continuous IV infusion can also provide improved health and economic benefits, such as patient convenience, as it allows for continuous drug administration in outpatient and home settings [3, 4].
Progress has also been made in the development of disposable portable infusion pumps—particularly elastomeric ones—which are reliable, consistent, easy to use, and have become widely available [5].

There are several types of elastomeric infusion pump; however, in Japan, physicians and pharmacists at various facilities are likely to choose which ones to use based mainly on cost and convenience. Elastomeric infusion pumps can be broadly classified into two types: those with hard and those with soft outer shells. To the best of our knowledge, no studies thus far have investigated whether hard- or soft-shelled pumps are preferable for patients undergoing pump-based treatments. In this study, we investigated patient preferences regarding the shell types of portable, disposable, elastomeric infusion pumps used for continuous IV infusion of 5-FU as a chemotherapy regimen for treating colorectal cancer, and the possibility of further improving patient satisfaction and quality of life with such treatments.

**Patients and Methods**

**Patients**

We recruited 20 outpatients aged ≥ 20 years who used portable disposable continuous IV infusion pumps for the delivery of colorectal cancer chemotherapy between October 1, 2020, and December 31, 2020, at the Multidisciplinary Treatment Center of Kurume University Hospital, and who had the cognitive ability to answer our questionnaire. Patients < 20 years of age and those deemed to have insufficient cognitive ability to answer the questionnaire were excluded.

**Study design**

Patients were first treated using the DIB Infuser® (DIB International Co., Ltd., Tokyo, Japan), a portable hard-shelled continuous infusion pump (Fig. 1a), and completed a questionnaire before the next treatment (hard-shelled arm). Each patient then received the next treatment using HOMEPUMP® (Avanos Medical Japan, Inc., Yokohama, Japan), a portable soft-shelled continuous infusion pump (Fig. 1b), and also completed the same questionnaire before the next treatment (soft-shelled arm). They were then asked which pump they would ultimately prefer for further treatments. The pharmacists who dispensed the drugs by injecting them into the two types of pumps were also asked to complete a questionnaire as an ancillary study.

**Questionnaire for Patients**

All patients who received chemotherapy using either type of pump were asked, via paper media, about the comfort of the pump (during the day, while out and about, and while sleeping), the ease of carrying the pump, the size and shape of the pump, the weight of the pump, the readability of the memory, and their overall satisfaction. A numerical rating scale was used to grade the responses [6]. The score was converted to 0 if the patient indicated they were not comfortable at all and 10 if they were very comfortable. Finally, we asked the participants which type of pump they preferred to use in the future. A free-response field was also added to the survey (Fig. 2).
Statistical analysis

To ensure the comparability of the results, both types of pumps (hard-shelled and soft-shelled) were used for each patient. Therefore, the Wilcoxon signed-rank sum test was used to analyze the results. All statistical analyses were performed using JMP version 16.0 (SAS Institute, Inc., Cary, NC, USA), and P-values of < 0.05 were considered statistically significant.

Ethical consideration

This prospective study was performed at Kurume University Hospital (Kurume, Japan). It conformed to the principles of the Declaration of Helsinki and was approved by the Ethics Committee of Kurume University (approval number: 20146). All patients and pharmacists provided written informed consent prior to enrollment.

Results

The 20 respondents with unresectable, advanced, recurrent colorectal cancer included seven men and 13 women. They had a median age of 68 years, a median height of 162.5 cm, a median weight of 55.2 kg, and a median body mass index (BMI) of 22.0 kg/m$^2$ (Table 1). Their responses regarding pump comfort revealed significantly higher satisfaction with the soft-shelled type during the daytime and when going out (P<0.001, P<0.001), but no significant difference when sleeping (P=0.05). In terms of portability, size, shape, and weight, the soft-shelled pump also scored higher than the hard-shelled type (P<0.001, P=0.0011, P<0.001). However, the hard-shelled type scored significantly better than the soft-shelled type in terms of ease of viewing the device's memory (P<0.001). The overall satisfaction was significantly higher for the soft-shelled type than for the hard-shelled type (P=0.0095; Table 2). In the end, 13 of the patients (65%) preferred a soft-shelled pump for their next treatment, one patient (5%) preferred a hard-shelled pump, and six patients (35%) indicated that either type of pump would be acceptable.

Using the median BMI (22 kg/m$^2$) as the cut-off, we also found that patients with BMIs of <22 kg/m$^2$ (n=10) were significantly more satisfied with the soft-shelled type than those with BMIs ≥22 kg/m$^2$ (n=10) in terms of comfort during the day, portability, size and shape, and weight (Table 3). We also found that women significantly preferred soft-shelled pumps over men, although there were no significant differences between the BMIs (Table 4).

The pharmacists who injected the 5-FU into each of the infusion pumps included eight male and four female pharmacists, with a median age of 36.0 years and a median of 13.0 years of experience as pharmacist (Supplementary Table S1). There was no significant difference between the two pumps in terms of the ease of drug injection (P=0.1211); however, satisfaction with the hard-shelled type was significantly higher than with the soft-shelled type in terms of the ease of viewing the device's memory (P<0.0010). Overall satisfaction with the hard-shelled type was also significantly higher than with the soft-shelled option (P=0.0352; Supplementary Table S2).
Discussion

The advent of FOLFOX and FOLFIRI as chemotherapy regimens for patients with unresectable, advanced, and recurrent colorectal cancer has not only improved life expectancy but has also made a significant contribution to quality of life by making outpatient treatment possible [7–9]. Continuous IV infusion of 5-FU is necessary to provide these treatments in an outpatient setting, therefore necessitating the use of a portable continuous infusion pump. However, some patients using infusion pumps report inconveniences in their daily lives during continuous administration while at home [10, 11]. To the best of our knowledge, this is the first report on patient preferences regarding portable disposable pumps for the continuous IV infusion of 5-FU at home.

In this study, patient surveys showed that overall satisfaction with the soft-shelled infusion pump was higher than it was with the hard-shelled infusion pump, with 65% of the patients indicating they would prefer to be treated with a soft-shelled pump. The reasons for this were that these pumps were easier to carry, had more convenient shapes and weights, and were less bulky than the hard-shelled type. These made them more comfortable for use during the day and while sleeping, meaning they were less obstructive to daily life. In a previous study on whether soft-shelled or hard-shelled devices for the at-home administration of antibiotics were preferred, 20/24 patients (83%) reported that they preferred soft-shelled devices [10], which agreed well with our results. On the other hand, many respondents preferred the hard-shelled pumps because they had scales on their sides that allows the patients to check how much liquid remained.

This study found a strong preference for soft-shelled infusion pumps, particularly among patients with BMIs of < 22 kg/m². Patients with lower BMIs are generally lighter and have less fat and muscle mass than standard-weight individuals, potentially making them more sensitive to the shapes and weights of their pumps. This suggests that soft-shelled infusion pumps have lower levels of physical impact on patients. Of the 13 patients (65%) in this study who ultimately requested treatments with soft-shelled pumps, 10 were women. The reason women prefer soft-shelled pumps over men despite no significant differences in BMI levels may be that they feel the effects of the pump more than men, although this could not be verified in this study because of the small number of participants.

In our survey, the majority of the patients preferred soft-shelled infusion pumps over hard-shelled ones. Interestingly, however, more of the pharmacists who loaded the pumps preferred hard-shelled versions in terms of overall satisfaction. The reason for this was that the force applied to the syringe when mixing the medications was lighter than what was needed for the soft-shelled infusion pumps and that the scale made preparation easier because it could be checked as needed. We therefore found that soft-shelled infusion pumps were preferred by patients, whereas hard-shelled ones were preferred by the pharmacists who prepared them.

Healthcare professionals are aware of adverse events such as nausea, vomiting, anorexia, other gastrointestinal symptoms, and peripheral neuropathy while administering FOLFOX, FOLFIRI, and other
therapies. Focusing on the quality of life after the pump is attached may also ease some of the treatment-related burdens on patients. It is presumed that in many facilities, physicians and pharmacists decide which portable continuous infusion pump to use based on convenience and cost; however, from the perspective of patient quality of life, the use of portable continuous infusion pumps that reflect patient preferences should also be considered. In particular, this study taught us that physicians and pharmacists, as members of the cancer chemotherapy team, should not only manage regimens, dosing schedules, and adverse events but also make every effort to improve the quality of life of their patients.

However, this study had several key limitations worth noting. First, the small sample size of infuser pumps available meant that only a small number of patients could be included. Second, only one questionnaire was completed for each infusion pump used, so repeated long-term assessments of quality of life were not possible. Third, the satisfaction rating was only assessed using the NRS. Future studies should consider these factors when focusing on the notable factors of BMI and the preferences of female patients.

This study revealed that more patients generally preferred soft-shelled infusion pumps over hard-shelled ones for delivering continuous colorectal cancer chemotherapy—particularly those patients with BMIs of < 22 kg/m² and female patients. These results suggest that, in the future, the selection of portable continuous infusion pumps that consider patient preferences may also help to further improve patient quality of life.

**Declarations**

**Acknowledgments**

We express our gratitude to all the patients and pharmacists who participated in this study. We would also like to thank Editage (www.editage.com) for their English-language editing.

**Conflict of Interest**

The authors declare that this study was conducted in the absence of any commercial or financial relationships that could be construed as potential conflicts of interest.

**Authors’ contributions**

Keisuke Miwa conceived the study and drafted the manuscript. Taku Yamada conducted the questionnaire, collected the clinical data, and wrote the manuscript. Kayoko Hashimoto and Eri Furukawa contributed greatly to the administration and collection of the questionnaires. Taketomo Kikuchi, Hirokazu Matsumoto, and Kazuki Tsutsumi contributed to drug dispensing and questionnaire collection. Toshimitsu Tanaka collected clinical data and contributed to data entry, management, and protection. Sachiko Nagasu was involved in the statistical analysis of the raw data. Taku Yamada and Keisuke Miwa created the figures. Sachiko Nagasu contributed to the creation of the tables. Kyouko Higuchi, Miho
Kugishima, Takumi Kawaguchi and Fumihiko Fujita supervised this study. Keisuke Miwa reviewed and edited the manuscript. All authors discussed the results and contributed to the final manuscript.

**Funding**

The authors received no particular funding for this work.

**Data Availability Statement**

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

**References**


Tables

Table 1 Patient characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, median, year (range)</td>
<td>68 (47-79)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>7</td>
</tr>
<tr>
<td>female</td>
<td>13</td>
</tr>
<tr>
<td>Height, median, cm (range)</td>
<td>162.5 (143.2-176.5)</td>
</tr>
<tr>
<td>Weight, median, kg (range)</td>
<td>55.2 (39.3-96.0)</td>
</tr>
<tr>
<td>BMI, median, kg/m² (range)</td>
<td>22.0 (17.6-30.8)</td>
</tr>
</tbody>
</table>

Abbreviation: BMI; body mass index

Table 2 Survey results of patients

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hard-Shelled arm (N=20)</th>
<th>Soft-shelled arm (N=20)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort</td>
<td>5.65±2.73</td>
<td>7.75±2.10</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Comfort daytime</td>
<td>4.90±3.16</td>
<td>7.70±2.10</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Sleeping</td>
<td>6.60±5.26</td>
<td>7.80±6.65</td>
<td>0.050</td>
</tr>
<tr>
<td>Portability</td>
<td>6.20±5.05</td>
<td>8.40±7.41</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Shape and size</td>
<td>5.95±2.76</td>
<td>8.30±1.87</td>
<td>0.0011</td>
</tr>
<tr>
<td>Weight</td>
<td>6.80±2.40</td>
<td>8.65±1.93</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Ease of viewing memory</td>
<td>7.80±2.35</td>
<td>4.70±2.60</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Overall satisfaction</td>
<td>6.15±2.48</td>
<td>7.50±1.99</td>
<td>0.0095</td>
</tr>
</tbody>
</table>
Abbreviation: SD; standard deviation

Table 3 Survey results of patients by body mass index (BMI)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>BMI &lt; 22 kg/m² [N=10]</th>
<th>BMI ≥ 22 kg/m² [N=10]</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort daytime</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>P-value</td>
</tr>
<tr>
<td>Going out</td>
<td>4.90±2.81</td>
<td>7.20±1.69</td>
<td>0.0156</td>
</tr>
<tr>
<td>Sleeping</td>
<td>6.70±2.79</td>
<td>7.30±1.77</td>
<td>0.4844</td>
</tr>
<tr>
<td>Portability</td>
<td>5.60±2.50</td>
<td>8.00±1.70</td>
<td>0.0078</td>
</tr>
<tr>
<td>Shape and size</td>
<td>5.70±2.79</td>
<td>8.60±1.26</td>
<td>0.0039</td>
</tr>
<tr>
<td>Weight</td>
<td>5.90±2.28</td>
<td>8.80±1.32</td>
<td>0.0078</td>
</tr>
<tr>
<td>Ease of viewing memory</td>
<td>8.40±2.01</td>
<td>4.50±2.80</td>
<td>0.0195</td>
</tr>
<tr>
<td>Overall satisfaction</td>
<td>6.00±2.71</td>
<td>7.00±1.63</td>
<td>0.1875</td>
</tr>
</tbody>
</table>

Abbreviation: BMI; body mass index, SD; standard deviation

Table 4 Survey results of patients by sex
Male \( \text{N=7} \)

median BMI: 23.8 kg/m\(^2\)

Female \( \text{N=13} \)

median BMI: 21.7 kg/m\(^2\)

\( p=0.2125 \)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hard-shelled arm</th>
<th>Soft-shelled arm</th>
<th>P-value</th>
<th>Hard-shelled arm</th>
<th>Soft-shelled arm</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td></td>
</tr>
<tr>
<td>comfort daytime</td>
<td>7.57±2.15</td>
<td>8.42±1.90</td>
<td>0.2500</td>
<td>4.61±2.50</td>
<td>7.38±2.18</td>
<td>0.0063</td>
</tr>
<tr>
<td>going out</td>
<td>7.14±2.67</td>
<td>8.43±1.91</td>
<td>0.1250</td>
<td>3.69±2.78</td>
<td>7.30±2.17</td>
<td>0.0024</td>
</tr>
<tr>
<td>sleeping</td>
<td>7.28±2.36</td>
<td>8.42±1.71</td>
<td>0.2500</td>
<td>6.23±3.13</td>
<td>7.46±2.78</td>
<td>0.2598</td>
</tr>
<tr>
<td>portability</td>
<td>8.00±1.82</td>
<td>8.71±1.97</td>
<td>0.1250</td>
<td>5.23±2.24</td>
<td>8.23±2.24</td>
<td>0.0034</td>
</tr>
<tr>
<td>Pump shape, size</td>
<td>8.14±1.77</td>
<td>8.42±1.39</td>
<td>0.7813</td>
<td>4.76±2.49</td>
<td>8.23±2.13</td>
<td>0.0029</td>
</tr>
<tr>
<td>Pump weight</td>
<td>8.14±1.95</td>
<td>8.80±1.32</td>
<td>0.1250</td>
<td>6.07±2.36</td>
<td>8.50±2.46</td>
<td>0.0117</td>
</tr>
<tr>
<td>Ease of viewing memory</td>
<td>7.85±2.26</td>
<td>5.85±1.95</td>
<td>0.0625</td>
<td>7.76±2.48</td>
<td>4.07±2.75</td>
<td>0.0027</td>
</tr>
<tr>
<td>satisfaction</td>
<td>7.71±1.79</td>
<td>7.85±1.57</td>
<td>0.7663</td>
<td>5.30±2.42</td>
<td>7.30±2.21</td>
<td>0.0195</td>
</tr>
</tbody>
</table>

Abbreviation: BMI; body mass index, SD; standard deviation

**Figures**
Figure 1

Two types of elastomeric pumps were used in this study.

a, the hard-shelled DIB Infuser®

b, the soft-shelled type HOMEPUMP®
**Figure 2**

The questionnaire used in this study (translated; the original version administered was in Japanese).

**Supplementary Files**

This is a list of supplementary files associated with this preprint. Click to download.
• SupplementaryMaterials.docx