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iPad-Based Patient Briefing for Radiological Examinations—a Clinical Trial

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Abstract To analyze if an iPad-based patient briefing can serve as a digital alternative to conventional documentations prior to radiological examinations. One hundred one patients referred for routine MRI were randomized into two groups, who underwent iPad-based and classic written briefing in opposite order. For each briefing completion time, completeness and correctness were noted. Patient's knowledge about the content of either briefing modality was subsequently tested. The influence of patient-related factors on the performance of the electronic briefing (EB) was analyzed. Finally, the patient's subjective impression of the EB was assessed. The mean durations were 4.4±2.2 min for EB and 1.7±1.3 min for the classic briefing ($p<0.01$). All iPad briefings were returned entirely filled out, whereas 11 % of the classic forms were returned with missing data. No significant differences in memorization of the briefing's information were objectified. There was a positive correlation between the duration of EB and age ($r=0.53$; $p<0.01$), whereas a negative correlation was found between computer skills and patient's age ($r=-0.55$; $p<0.01$) or duration of EB ($r=-0.62$; $p<0.01$). More than half of the study patients would prefer EB in the future; another 29 % had no preference at all. Patient briefing on iPads transfers the information for the patients equally well compared to the classic written approach. Although iPad briefing took patients longer to perform, the majority would prefer it to written consent briefings in the future. Nevertheless, measures have to be undertaken to improve the overall acceptance and performance.

Keywords Clinical application · Acceptance testing · Data collection · Electronic patient consent · Tablet PC

Introduction

Since the introduction of the iPad® by Apple (Cupertino, CA, USA) in 2010, modern tablet computers (TC) have become increasingly popular [1]. One reason for the broad acceptance of TC lies with their compact design and portability thus making TC interesting for medical or research applications too [2–10]. Another, if not even more important feature, is their intuitive interface with direct on-screen interaction. This transformation ability of the interactive on-screen components makes TCs such as the iPad interesting for clinical applications too. In particular, patients may profit from the variability of on-screen interaction, e.g. for collection of patient data using the iPad prior to radiological examinations. Therefore, a TC-based patient briefing had been introduced recently and proved a feasible method of electronic data capture which might allow instant analysis and post processing of patient data [11]. With the introduction of this novel way of patient briefing, the question arose as to whether or not this could be an alternative to the paper-based version of patient briefing before radiological examinations and how a larger collective of patients would deal with this way of information transfer.

Therefore, the purpose of this clinical trial was to analyze if a customized iPad-based patient briefing can serve as a digital alternative to conventional paper documentations.

Materials and Methods

This study was conducted in accordance with the guidelines of the Declaration of Helsinki and approved by the local ethics committee.

Philipp M. Schlechtweg and Matthias Hammon contributed equally to the study.

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For the clinical trial, a custom-made iPad application ('app') was used as described before [11]: The source document for the app is our standard MRI briefing sheet, which was designed up by our institute and is employed as a paper printout. The content of the paper briefing was transferred one-to-one to the digital briefing version and converted into an application for the iPad, so that there was no difference in the informational content in both briefing modalities. The electronic briefing uses a design of subsequent screens with large fonts and easy-to-apply, large on-screen buttons. The patient interacts with the iPad via its touchscreen display using a dedicated pen or his/her fingers. One can only proceed to the next step if—on the currently viewed screen—the question has been answered, a required field filled out or a text actively confirmed as 'read' by the patient (Fig. 1).

Patient exclusion criteria included emergency admittals and patients age under 18 years old. Additionally, patients with reduced consciousness, mental or physical disabilities and/or language problems preventing a proper interaction with the iPad were not included. One hundred twelve consecutive patients who visited our MRI department and met our inclusion criteria were asked whether they had already been briefed on the current examination and if they were interested in participating in the study. Those patients who answered the first question in the negative and who were willing to participate (n=101) were included in the study (49 males, 52 females, mean age 49 years, range 18 to 80 years, standard deviation±16.8 years). Eleven of 112 patients rejected participation in the study.

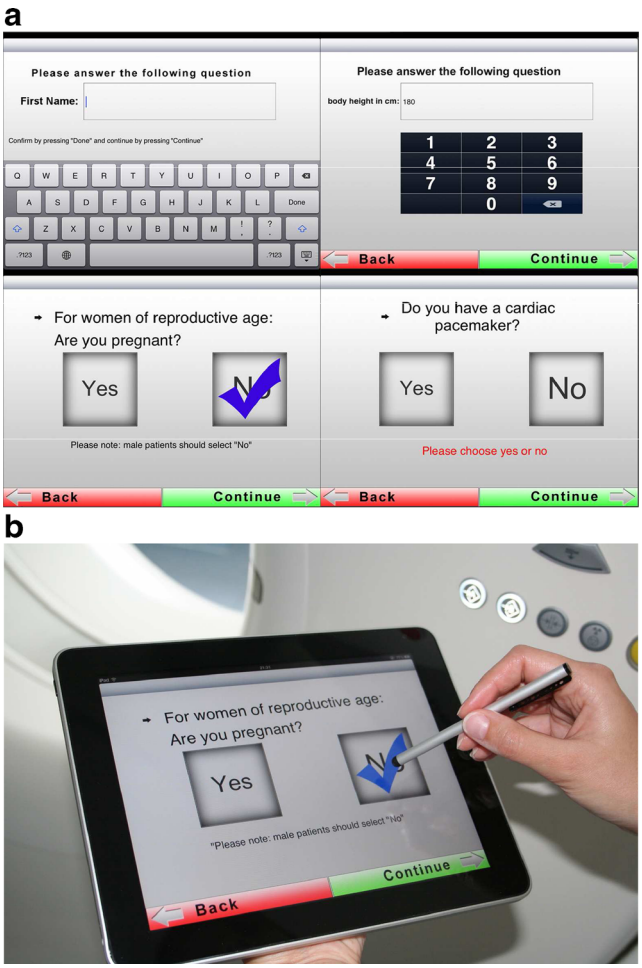

Fig. 1 **a** Four screenshots of the electronic iPad-based briefing. The *upper row* shows examples of acquisition of general patient data such as first name (*upper left*) or his/her height (*upper right*). The *lower row* gives examples of more examination-specific questions such as the question of possible pregnancy (*lower left*) or of a cardiac pacemaker (*lower right*). **b** The patient interacts with the iPad via its touchscreen display using a dedicated pen (as shown in the figure) or his/her fingers

At first, study relevant data (e.g. age or gender) of the participants were gathered and noted down separately on a participant list. Additionally, the patients' technical knowledge regarding computers ('computer skills') in general were assessed using four dedicated questions; high scores meant high skills whereas lower scores reflected lower computer knowledge (Table 1).

In a second step, the 101 participants were randomized into two groups: Group 1 (n=49) was asked to perform the iPad-based briefing first and group 2 (n=52) to fill in the conventional printout of the briefing document first.

Subsequently—to test the patient's memorization of the briefing's informational content—a questionnaire with six dedicated questions concerning the information given in both briefing modalities was filled out. Thereafter, the alternative modality of briefing was performed by each group. Thereby, group 1 and 2 eventually did both digital and conventional briefing but in opposing order.

For the iPad application, a short technical instruction on how to use the iPad (roughly 5 min) was provided, whereas later on the study, performers remained in the background; moreover, a permanent, active assistance to the patients was not provided. Generally, in both groups, the performers only answered questions if they were asked anything specific regardless of whether during the conventional or during the app-based briefing. Number and nature of these questions as well as the total time the participants needed for each briefing modality were measured and documented. Immediately after being returned, the conventional forms and the electronic briefings were checked as to whether they were entirely completed or if anything had been skipped or filled out incorrectly, all of which was noted.

Table 1 Questionnaire to assess patients' knowledge regarding computers. Possible answers 1 to 6; 1=I strongly disagree, 6=I strongly agree

I am familiar with computers
My private environment is heavily IT-oriented
My work environment is heavily IT-oriented
I am familiar with apps on smartphones and/or tablet PCs

After each participant, the iPad's surface was cleaned with a surface disinfection agent (Incidin plus®, Ecolab, Düsseldorf, Germany).

After the completion of both briefing modalities, an additional questionnaire consisting of 11 questions regarding the patient's subjective impressions and opinions regarding the iPad app was filled out; high scores meant high acceptance whereas lower scores reflected discontent (Table 2).

Finally, patients were asked which modality they would prefer in the future and if they had any wishes for updated versions of the app.

The entire study design is shown in Fig. 2.

Statistical analysis was performed using a dedicated software (SPSS Statistics v20, IBM, Armonk, USA). Student's *t* test and a chi-squared test were applied, respectively. *p* Values <0.05 were considered as significant.

Results

In all 101 patients, the entire study protocol was completed; none of them cancelled their participation. All patients returned their iPad briefing entirely filled out, whereas 11 % of the classic forms were returned with missing data.

Group 1 (n=49) consisted of 24 males and 25 females aged between 18 and 78 years old (mean 50±17.4), whereas in group 2 (n=52), the age of the 25 males and 27 females ranged from 19 to 80 years old (mean 48±16.3). There were no significant differences between group 1 and 2 regarding participants' age (p>0.48) and gender (p>0.76).

Patients in both groups answered correctly to 5.51 of the 6 questions testing the memorization of the briefing's information (range 3–6). Analyzing the results in both particular groups (4 or less vs. 5 vs. 6 correct answers) there was no significant difference between both groups (p>0.16).

Table 2 Questionnaire regarding the patient's subjective impressions and opinions regarding the iPad app. Possible answers 1 to 6; 1=I strongly disagree, 6=I strongly agree

I like the optical realization of the electronic briefing
The electronic briefing is clearly arranged
The handling is easy, intuitive and quickly comprehensible
For me, as a patient, the electronic briefing means a relief
I could perform the entire electronic briefing without additional help
The texts of the electronic briefing were clearly legible
I think I understood the information given in the electronic briefing
The content of the conventional briefing has been transferred excellently into the electronic form
The expenditure of time for absolving the electronic briefing is adequate
Conventional briefing should be replaced by electronic briefing in the future
The electronic briefing is nicely done

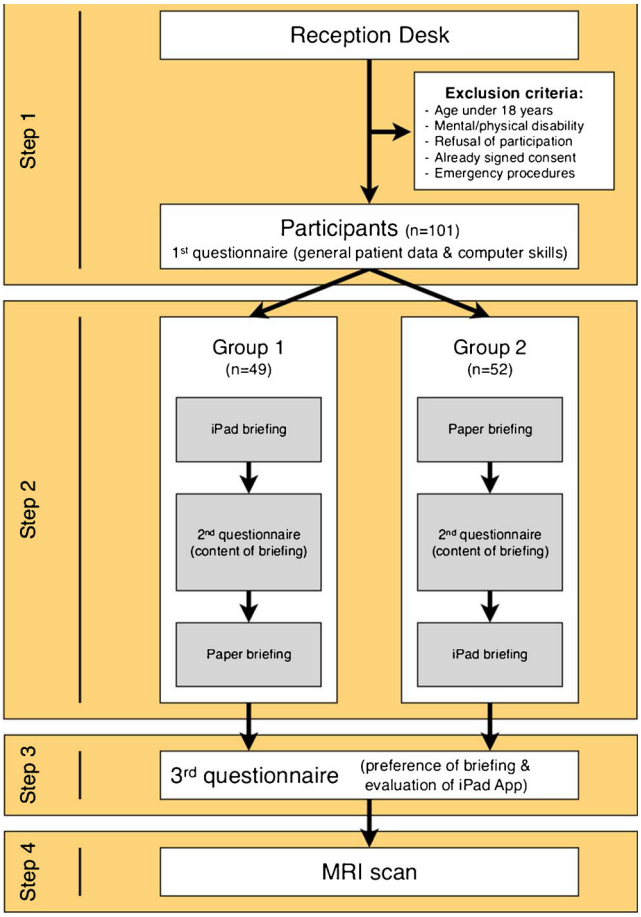

Fig. 2 Flow chart reflecting the study design. Patients referred for routine MR Imaging were asked if they were willing to participate in this study; exclusion criteria are shown (*step 1*). Participants were divided into two groups who underwent the iPad-based briefing and the conventional paper form in opposing order. Between the two briefing modalities, patients' memorization of the content was tested (*step 2*). Once both briefings were entirely filled out, all participants were interviewed concerning their subjective impressions of the iPad briefing (*step 3*). After completion of this third questionnaire, patients underwent their MRI scan (*step 4*)

The mean total time for the electronic briefing was 4.7± 2.3 min in group 1, whereas it was 4.1±2.1 min in group 2, which was not statistically different (p>0.2).

The mean duration of the electronic briefing in both groups together (n=101) was 4.4 min (SD 2.2 min), whereas it was 1.7 min (SD 1.3 min) for the classic written briefing; the difference was highly significant (p<0.01).

As shown in Fig. 3, there was a significant positive correlation between the duration of the electronic briefing and patient's age (r=0.53; p<0.01). There was no significant correlation between gender and duration of the iPad briefing (r=0.14; p>0.17).

In regard to the four questions on computer skills, participants' (n=101) mean score was 15.4 (64 %) out of a maximum total value of 24 points. As shown in Fig. 4, there was a significant negative correlation between the total scores of

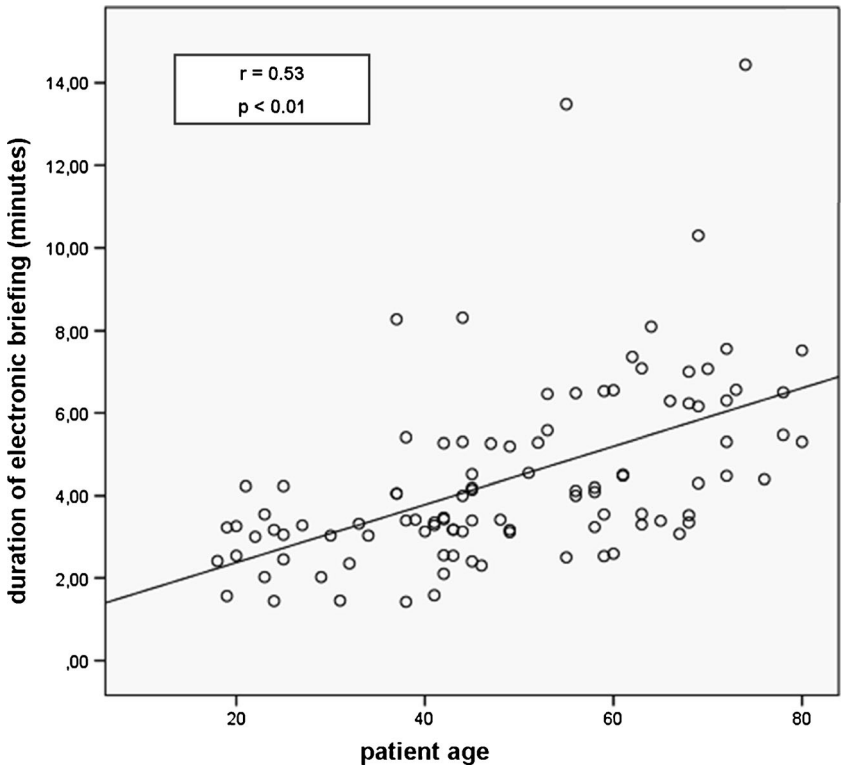

Fig. 3 Influence of patient age on total duration of electronic briefing on the iPad (n=101)

computer skills and patient's age (r=−0.55; p<0.01). Women achieved a mean total score of 14.38 (±5.3), whereas male participants achieved a mean score of 16.45 (±4.41) which was slightly significant (p=0.036; see Fig. 5). A negative correlation was found between computer skills scores and duration of the electronic briefing (r=−0.62; p<0.01) as shown in Fig. 6.

While not permanently assisted, patients nevertheless had the possibility to ask questions during the electronic and classic briefing about the medical content or the general handling of the tablet computer. For electronic briefing, 14 % of patients had four or more questions about the correct handling of the touchscreen or the interactive fields in the app, 14 % had three, 21 % had two, 19 % had one question and 33 % performed the entire electronic briefing without any questions about the handling of the iPad app. With classic briefing only, 2 of 101 patients had formal questions regarding completing the form, whereas no formal questions were asked by 98 % of the patients.

Contrary to this, in regard to the medical content of the briefings (e.g. former surgical procedures, known allergies, metallic implants, …), the number of questions per patient were almost equal to the iPad app (mean 0.27 questions/patient±0.615) and with the classic form (mean 0.24 questions/patient±0.532).

There was a significant correlation between the number of questions and duration of the electronic briefing (p<0.01).

Being asked how patients would like to perform future briefings, 52 % preferred the electronic variant, 19 % the classic written consent and 29 % had no preference at all. Of the entire study group, 3 % wished for more informational media in the app, e.g. movies, audio clips or pictures, and 16 % said that the briefing should be performed faster, no matter what modality.

The questionnaire about the contentment using the iPad app resulted in a mean acceptance score of 56.21 (SD 6.15) out of a possible maximum of 66 points. There was a slight negative correlation between the appraisal of the app and age (r=−0.39; p<0.01), whereas no significant correlation was found between overall impression and gender (r=0.02; p=0.801). Less formal questions during the electronic briefing correlated with a higher acceptance score (r=−0.35; p<0.01). Higher computer skills correlated with a higher acceptance score (r=0.31; p<0.01).

Discussion

In this study, we compared an electronically based patient briefing on an iPad before MRI with the traditional written approach. Thereby, two statistically comparable groups of patients performed both briefing modalities in opposing order. Performing the electronic briefing took more than twice as long as the written consent. The longer duration of the iPad briefing stands in contrast to the advantages of the electronic

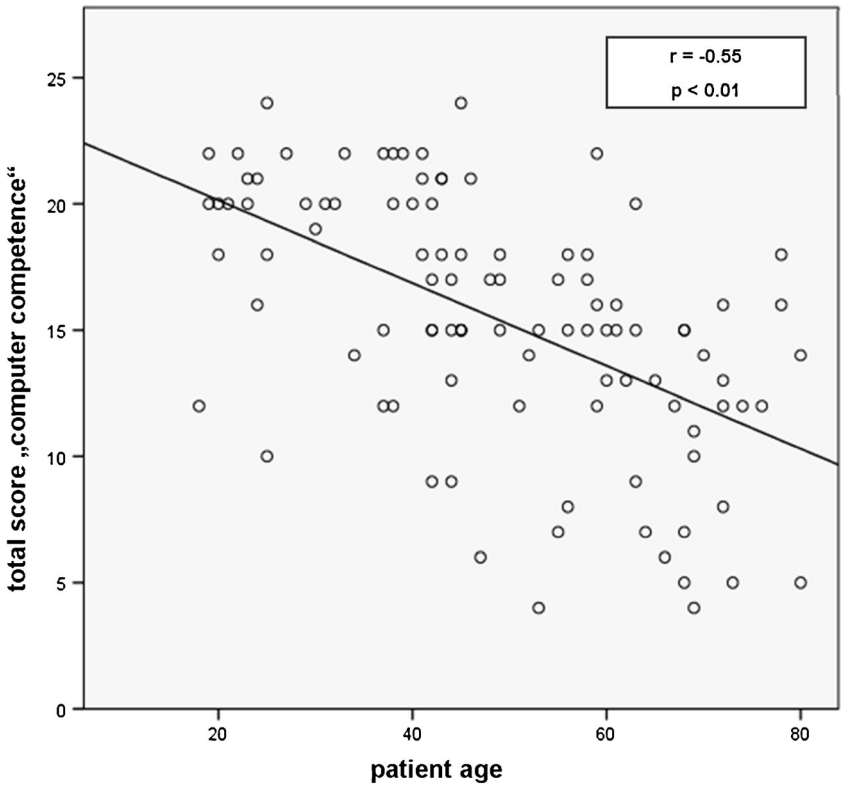

Fig. 4 Correlation between patient age and total score on computer competence (n=101)

briefing, most notably the possibility of a timely direct acquisition of digital data from patients and the avoidance of incomplete briefing forms being returned. The memorization of the content of the iPad app showed no statistically significant differences compared to the classic paper-based approach.

As expected, the older the patients were, the longer it took them to complete the electronic briefing (Fig. 2). Theoretically, this may be due to physiological restrictions elder patients are confronted with (e.g. impaired sight or motor deficits). However, as the design of the iPad app was developed with the intention of producing a user surface with large fonts and

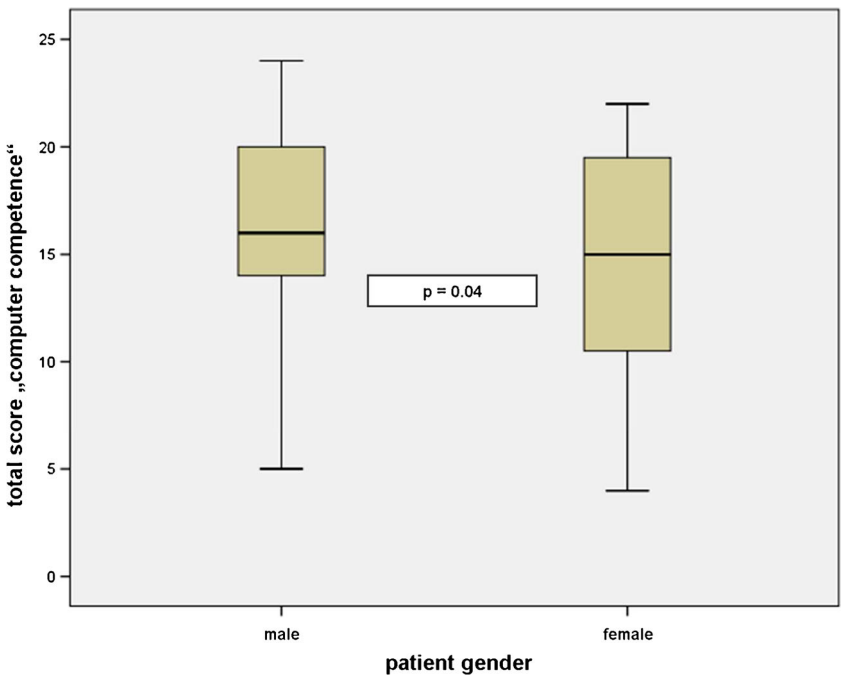

Fig. 5 Total scores on computer competence in men and women (n=101)

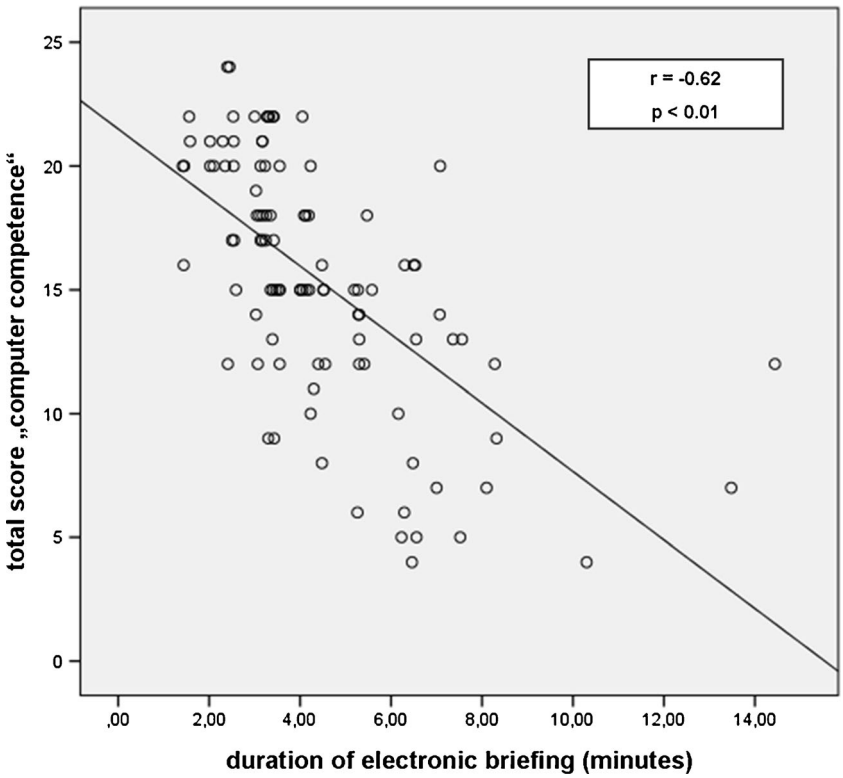

Fig. 6 Correlation between total scores on computer competence and duration of electronic briefing (n=101)

easy-to-apply, large on-screen buttons on the one hand, and physically and/or mentally impaired patients were excluded from the study on the other hand, we believe that physical restrictions were of minor importance in regard to the age dependency on digital briefing time.

A high impact on performance time was the total score of computer skills, which is reflected by Fig. 5. Moreover, the total amount of formal questions during the briefing resulted in a significant prolongation of the entire procedure. Other factors seem to be only secondary (e.g. age generally resulted in lower scores in computer skills) or even negligible (such as the fact that women had slightly lower computer skills than men). As the age or gender distribution of knowledge in computers is not a static phenomenon but is a matter of dynamic change over time, the acceptance of tablet computers by patients—even the elderly—is most likely to improve significantly in the future [9, 12]. Nevertheless, measures have to be undertaken to make this interaction more intuitive which is reflected by the rather large number of questions that arose during the electronic briefing concerning the interaction with the tablet computer. Not surprisingly, more questions led to a significant rise in briefing time. In contrast, the dramatically lower number of questions during the classic briefing led to a much faster performance. However, it has to be kept in mind that this apparent time advantage of the paper-based approach can be explained to a certain extent by the possibility of skipping points in a paper form which is reflected by a rather high rate of returned incomplete forms which was 12 %. Incomplete briefing documents produce additional work in additional interviews of the patients and therefore reduce the primary saving in time of classic written consents. In regard to completeness of the briefings, the main advantage of the iPad form lies with its consecutive interview style: The patient can only proceed to the next step by answering the current questions, whereas in written consents, our data reflect the well-known patient's practice of skipping questions or points on conventional forms. As incomplete forms are of both ethical and legal concern, an electronic briefing could improve quality of patient briefing in both aspects and can contribute to safer processes in pre-imaging patient management.

Interestingly, although electronic briefing took our patients significantly longer than the written variant, majority (52 %) of patients liked the electronic briefing although it took them significantly longer to perform it. Of the patients, 3 % wished to have more multimedia content in the iPad app such as movies, audio clips or pictures. Another 29 % did not have any preference at all. Sixteen percent wished briefing to be performed more quickly, no matter what modality. To find out more about patients opinions on electronic briefing, a questionnaire was filled out at the end of the study, consisting of 11 questions about the iPad app (Table 2). Lower patient age and higher computer skills correlated with high acceptance scores of the iPad app. This was not surprising, as computer competence was lower at higher ages (Fig. 4). The overall appraisal of the electronic briefing decreased with the number of questions that arose during the handling of the app.

To the best of our knowledge this is the first clinical trial on tablet computer-based patient briefing before radiological examinations. Tait et al. compared patient briefing before diagnostic cardiac catheterization using either standard verbal and written information or interactive computerized information on laptop computers [13]. Contrary to our results—where no significant difference in knowledge after either briefing modality was observed—the patients in their computer-briefed group had significantly greater improvement in understanding the subsequent procedure. This may be explained by the fact that many of our patients receive MRI repetitively and thus may have had a lot of knowledge prior to their participation in our study. This limitation could be overcome in future studies, where only patients without any prior MRI should be included. On the other hand, the computer briefing in their study had much more information than the traditional information, and thus, a direct comparison seems to be difficult. In another recent study, Rawbothan et al. compared interactive informed consents on iPad with standard paper consents before a clinical research study. The iPad group in their study had significantly higher test scores than standard paper consent subjects [9]. Similar to the study of Tait et al., the reason for the success of their iPad consent most probably lies with the much higher amount of content of the iPad consent (video, forms, multiple choice test) compared with the standard paper consent.

As the information given on paper and iPad briefings was identical in our study, a direct comparison with their results seems unfeasible. However, although the iPad consent took their patients longer than the paper-based approach, overall satisfaction favoured the interactive iPad presentation, which correlates with our observation that patients seem to enjoy the computerized briefing.

An advantage of the iPad-based briefing could be found in the fact that the information from completed patient forms could be added more easily and quickly to a digital patient portfolio in the radiological information system (RIS) or other databases. This, for example, would allow the automatic generation of warnings such as ‘caution, patient has a cardiac pacemaker’. Moreover, the sometimes hard-to-read handwriting of patients on conventional forms can be avoided using electronic devices.

To avoid the spread of pathogens, the iPad was cleaned with a dedicated surface-disinfection agent after each participant.

Conclusions

Patient briefing on modern tablet computers such as the iPad is a promising alternative to the classic paper-based approach. Its main advantages lie with a timely direct acquisition of digital patient data and the avoidance of returned incomplete briefing forms. Nevertheless, measures have to be undertaken to improve the overall acceptance especially in the elder population and in individuals with lower levels of computer knowledge.

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