Upright Cancer Therapy: A Human Factors perspective

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SUMMARY

This paper explores the potential benefits and limitations of upright therapy compared to the traditional supine approach, focusing on the human factors perspective. The research is based on a combination of literature review, workshops with patients and clinicians, and ergonomic analysis. Upright therapy shows promise as a potential alternative to supine therapy, offering benefits for both patients and clinicians. Further research is crucial to fully understand the benefits of upright therapy for effective treatment approaches for various conditions and adaptability across various treatment conditions and requirements.

KEYWORDS

Supine vs Upright therapy, Radiation treatment, Human Factors, Patient experience, Clinical benefits

Introduction

In the realm of radiation therapy, advancements have continuously propelled the field towards enhanced precision and efficacy. Among these advancements, the transition from traditional supine radiation therapy to the innovative approach of upright radiation therapy stands as a significant evolution. This shift not only challenges conventional practices but also underscores the pivotal role of human factors in shaping the landscape of healthcare delivery.

Traditionally, supine radiation therapy has been the standard approach, offering stability and familiarity to both practitioners and patients. However, the emergence of upright radiation therapy introduces a shift by capitalizing on the ergonomic benefits and physiological advantages of upright positioning. This approach not only reimagines patient positioning but also redefines the interplay between technology, human interaction, and therapeutic outcomes.

This paper aims to delve into the comparative analysis of supine and upright radiation therapy, shedding light on their respective merits, limitations, and implications from a human factors lens. This paper aims not only to highlight the transformative potential of upright therapy but also to pave the way for further research, broader adoption and ultimately, more effective cancer care.

Methods and findings

Phase 1: Literature Review and Research Inquiry

The research was motivated by a desire to explore and understand the practical limitations and benefits of supine therapy and upright therapy in clinical settings. The literature review focused on identifying the benefits and limitations of supine therapy and upright therapy. By dissecting these dimensions, we can decipher the intricacies of how each modality influences human performance, decision-making processes, and overall system resilience within the clinical environment. The

research began by conducting a comprehensive search using academic databases like PubMed, Google Scholar, or relevant medical physics journals. Use keywords such as "patient positioning", "radiation therapy system", “radiation therapy”, “clinical benefits”, “patient comfort” and "supine vs. upright therapy."

While the primary interest of the research lies in radiation therapy products, the literature review delved specifically into the topics of supine and upright patient positioning rather than the nuances of imaging or treatment modalities themselves. However, it's important to note that the findings gathered from studying positioning are indicative and applicable across various modalities. The literature review identified the following benefits and limitations.

Benefits

Supine therapy

Supine therapy offers several advantages in radiation treatment. Firstly, it provides subjective comfort benefits to some patients during longer sessions. (Steris, 2021), (Gückel et al., 2015). Secondly, various immobilization techniques, like vacuum cushions and headrests, minimize patient movement (Verhey, 1995). Additionally, supine positioning is favoured for its ease of setup and reproducibility (Frøseth et al., 2015). Moreover, its widespread use means technicians and radiologists are more proficient in this positioning, contributing to its ease of use. Lastly, the supine position allows optimal access to anterior body structures and ensures stability on the surgical table (Steris, 2021).

Upright therapy

Upright positioning offers numerous clinical benefits, including expanded treatment options for challenging cancers such as lung, breast, and head and neck cancers (Dellamonica et al., 2013; Probst et al., 2022; Alghadir et al., 2017; Hegarty et al., 2022), respiratory motion management (Boisbouvier et al., 2021)), as well as organ sparing due to reduced movements (Hegarty et al., 2022). Enhanced target visualization enables more precise radiation delivery, potentially improving tumor control and patient outcomes (Boisbouvier et al., 2021; Schreuder et al., 2022; Von et al., 2007). Upright positioning also enhances patient comfort, particularly for those with breathing difficulties or swallowing issues (Alghadir et al., 2017; Court et al., 2013; Gückel et al., 2015; Niehoff et al., 2022), and promises cost reduction by lowering infrastructure costs and integrating seamlessly into existing treatment facilities (Thomas et al., 2021). Additionally, improved respiratory gating and minimized organ shifting contribute to treatment efficiency and cost-effectiveness (Von et al., 2007; Buchner et al., 2020; Thomas et al., 2021; Boisbouvier et al., 2022).

Limitations

Supine therapy

Supine therapy presents several challenges in radiation treatment. Inadequate accounting for respiratory motion in the chest and abdomen can diminish treatment accuracy (Thomas et al., 2021; Dellamonica et al., 2013), while achieving optimal dose distribution while minimizing exposure to healthy tissues proves challenging (Frøseth et al., 2015). Certain imaging modalities may be less effective in the supine position, leading to limitations in organ visualization (Volz et al., 2022). Additionally, traditional gantry systems for supine therapy require significant infrastructure footprint due to their size, making proton therapy a limited resource due to high capital costs and space requirements (Thomas et al., 2021; Buchner et al., 2020). Organ shift and anatomical changes during treatment or imaging sessions further complicate matters (Von et al., 2007; Schreuder et al.,

2022), potentially increasing the risk of skin due to higher doses of radiation to the skin in the treatment field.

Upright therapy

Limited clinical data is available on the long-term efficacy and safety of upright radiation therapy compared to supine therapy (Schreuder et al., 2022). Implementing upright positioning may necessitate adapting to new equipment or procedures, resulting in an initial learning curve that can affect workflow efficiency. Furthermore, not all patients can tolerate being in an upright position for extended periods, particularly those with limited mobility or balance issues. While chairs for radiation therapy have been utilized for patients unable to tolerate the lying position, they remain an exception rather than the norm (McCarroll et al., 2017; Court et al., 2013).

While both positions have their merits, the choice between supine and upright positioning should be carefully tailored to individual patient needs, treatment requirements, and available resources, emphasizing a patient-centered and evidence-based approach to radiation therapy delivery. Building upon these insights from a comprehensive literature review in Phase 1, then next phase of the research was aimed to gather real-world experiences and perspectives on supine and upright therapy.

Phase 2: Engagement Workshop

A workshop day was conducted with ten participants. seven cancer survivors (representing prostate, breast, and head and neck cancers) and three clinical experts to gather real-world experiences and perspectives on supine and upright therapy. The workshop employed semi-structured discussions guided by open-ended questions. The workshop aimed to uncover experiences and perspectives related to patient comfort, user experience and clinician ergonomics in traditional supine therapy and emerging upright therapy settings. Through open dialogue, participants shared their perspectives on various aspects, including comfort, physiological, psychological effects, workflow efficiency, and ergonomic ease of use.

The session began by gathering insights from both patient participants and clinical experts. Patients shared their personal experiences and perspectives on supine therapy, while clinical experts offered professional critiques, observations, and suggestions for improvement. This initial stage provided a comprehensive understanding of the current state of supine therapy.

Next, participants were given an opportunity to have some time on the upright patient positioning system (Leo Cancer Care, 2021). Patients and clinicians experienced the system firsthand, allowing them to assess its usability, comfort, and potential therapeutic benefits. Human Factors experts observed these interactions, noting any clinical implications and feasibility considerations. Finally, a reconvening discussion facilitated the sharing of valuable insights. Patients compared their experiences with the upright system to supine therapy, while clinical experts offered their expertise of its clinical usability.

Throughout the session field notes were taken to capture the qualitative data. Thematic analysis was performed to identify broad themes that were discussed by participants either based on the number of times that participants mentioned the theme and those that had identified use difficulties. The themes identified were categorised into the main topics, forming the basis for the results presented in this section.

Figure 1: Example Supine positioning for prostate

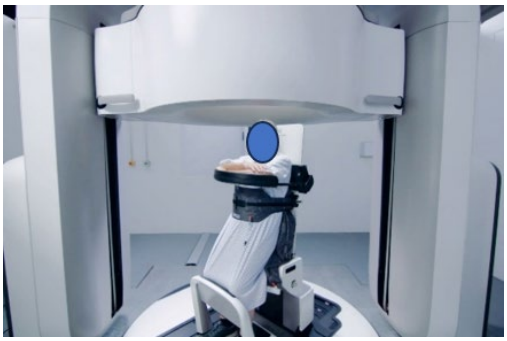


Figure 2: Example Upright positioning for prostate

From the feedback of the cancer patients several key pain points about supine therapy emerged:

- Lack of comfort and feeling "exposed": Many patients described discomfort in the supine position, likening it to lying in an uncomfortable block of table. This created a sense of vulnerability and reduced control over the situation.
- Communication barriers: Limited ability to chat or easily see the therapist during treatment contributed to feelings of isolation and anxiety.
- Physical discomfort due to treatment area: Certain treatments in supine positions were particularly uncomfortable, especially for those dealing with saliva accumulation and swallowing difficulties.

These insights highlighted the need for alternative approaches to radiation therapy that could address these concerns and improve the overall treatment experience.

Feedback collected post-experiencing an upright patient positioner underscored the potential of upright therapy to mitigate the challenges associated with supine therapy.

- Enhanced Comfort and Security: By allowing patients to sit or stand in a more natural position, upright therapy alleviates pressure points and promotes a sense of security and self-determination. The ability to see and communicate with the therapist fosters a more open and collaborative treatment experience.
- Reduced Physical Discomfort: For patients with specific treatment areas requiring different postures, upright therapy offers options to minimize discomfort and improve swallowing, leading to a more manageable experience.

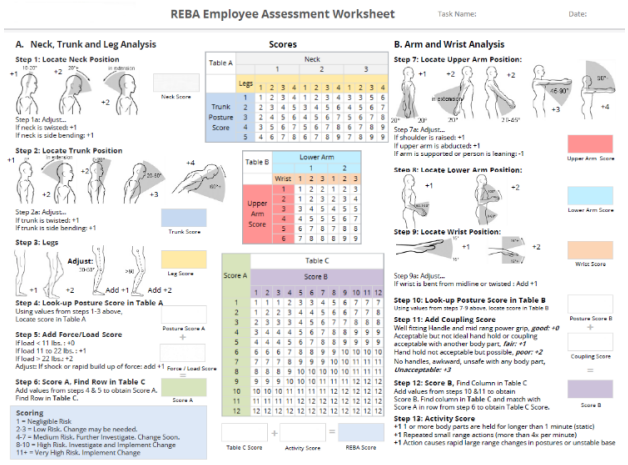
Further research and analysis, incorporating quantitative data and broader studies, can establish a strong foundation for understanding and quantifying the impact of upright therapy on patient experience. While Phase 2 highlighted the discomfort and anxiety associated with supine positioning for patients, it also unveiled a crucial concern for clinicians: physical strain. From the feedback of the clinicians several key pain points about supine and upright therapy emerged. Supporting patients, especially those with limited mobility, and manoeuvring immobilisation devices can be physically demanding, leading to potential muscle and joint strain. Individual patient characteristics like age, mobility, medical conditions influence the challenges faced by clinicians in both positions.

Phase 3: Ergonomic Analysis

To further investigate and understand the risk of musculoskeletal disorders and clinician ergonomics in supine vs upright therapy settings, feedback from clinical experts was collected for selecting the most frequently used body postures for positioning patients. The feedback was used to

conduct a Rapid Entire Body Assessment (REBA) analysis (Hignett, S. et al, 1998) on both upright and supine patient positioning postures. Prostate patient setup was particularly considered for this evaluation because of the demographic of frail and vulnerable elderly patients commonly treated in such settings. With the sparse availability of the upright systems in the market, the analysis was conducted using videos of an upright patient positioning system [Leo Cancer Care, 2023b] and a supine system (RAYUS, 2019) found on YouTube. Screenshots from these videos were then used for the REBA analysis. It's important to note that while the supine images analysed are of an MRI system and may not specifically represent radiation therapy. The focus was on posture rather than the specific type of imaging modality. So the images are indicative of the challenges associated with supine therapies in general.

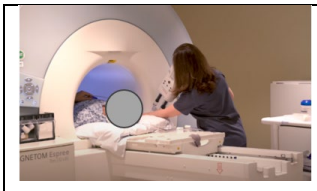
The REBA analysis provided insights into the potential reduction of musculoskeletal disorders (MSDs) among clinicians. REBA was developed by Hignett and McAttamney (Hignett, 1998; McAtamney and Hignett,1995). It is used to assess the entire body postural musculoskeletal disorders and risk associated with the job tasks. A single worksheet (figure 3) is used to evaluate the entire body posture, forceful exertion, type of movement, action, and repetitive work. The worksheet scores for each of the following body region: wrist, forearm, elbows, shoulder, neck, trunk, back, legs and knee. The score is collected and compiled to form a single score that represents the level of musculoskeletal disorder risk.

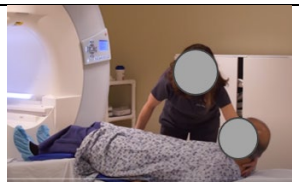


Score	Level of MSD Risk
1	negligible risk, no action required
2-3	low risk, change may be needed
4-7	medium risk, further investigation, change soon
8-10	high risk, investigate and implement change
11+	very high risk, implement change

Figure 3: Rapid Entire Body Assessment Worksheet and Risk Levels

The output of the Rapid Entire Body Assessment worksheet is the final REBA Score, which is a single score that represents the level of MSD risk for the job task being evaluated. The REBA level of MSD risk descriptions and cut points are Outlined in the above chart (figure 4). The minimum REBA Score is 1, and the maximum REBA Score is 11+ and above.


Posture 1


Posture 2


Posture 3


Posture 4

Figure 4: Images of supine positioning – table shows 4 different postures

Table 1: REBA scores for supine positioning

Posture	Posture #	Neck score	Trunk score	Leg score	Posture score A	Force/ load score	Score A	Upper arm score	Lower arm score	Wrist score	Posture score B	Coupling score	Score B	Table C score	Activity score	Final REBA score	Risk Rating
Supine	Posture 1	3	3	1	5	2	7	3	2	1	4	0	8	11	1	12	Very high
Supine	Posture 2	1	4	1	3	3	6	3	1	2	4	0	4	7	1	8	High
Supine	Posture 3	1	2	1	2	2	4	2	1	1	1	0	1	3	1	4	Medium
Supine	Posture 4	2	4	1	5	3	8	2	2	2	3	0	3	8	1	9	High

Posture 1

Posture 2

Posture 3

Posture 4

Figure 5: Images of upright positioning – table shows 4 different postures

Table 2: REBA scores for upright positioning

Posture	Posture #	Neck score	Trunk score	Leg score	Posture score A	Force/ load score	Score A	Upper arm score	Lower arm score	Wrist score	Posture score B	Coupling score	Score B	Table C score	Activity score	Final REBA score	Risk Rating
Upright	Posture 1	1	3	1	2	0	2	2	1	1	4	0	4	3	1	4	Medium
Upright	Posture 2	1	2	1	2	0	2	1	1	1	3	0	3	2	1	3	Low
Upright	Posture 3	2	2	2	4	0	4	1	1	1	3	0	3	4	1	5	Medium
Upright	Posture 4	1	2	1	2	0	2	1	1	1	3	0	3	2	1	3	Low

Interpretation:

A clear distinction emerges when comparing the ergonomic risks of upright and supine postures based on the REBA scores:

- Upright postures: Two out of four postures (2, and 4) exhibit low risk scores (3), indicating minimal ergonomic concerns. Even posture 1 and 3, with a medium risk score (4 and 5), falls within a medium risk range.
- Supine postures: Only one posture (3) has a medium risk score (4). The remaining postures have high risk scores (8 and 9) and a concerning high risk score (12), highlighting significant potential for discomfort and musculoskeletal strain.

By comparing the REBA scores of four different postures in each position, we gain valuable insights into their potential impact on user experience and safety. The observed differences in the ergonomic risk between supine and upright positions can be attributed to several factors like accessibility, manoeuvrability, space availability, physical strain, and patient characteristics like mobility, size, medical conditions. Table 3: reasons contributing to the different REBA scores.

Upright	**Supine**
Access and manoeuvrability: Allows clinicians to stand at a comfortable distance, enabling them to easily reach all sides of the patient for adjustments and positioning. This eliminates the	Access and manoeuvrability: Often restricts access to certain areas of the patient's body, requiring clinicians to contort themselves into uncomfortable positions to reach them. Or

need for awkward bending, reaching, and twisting associated with supine positioning.	support frail patients who have reduced mobility. This can increase the risk of musculoskeletal strain.
Physical strain: Promotes a more natural body posture for clinicians, minimizing strain on the neck, back, and shoulders. This is because the weight is distributed evenly across both legs, and the spine remains in a more neutral alignment.	Physical strain: Often requires clinicians to hunch over, bend at the waist, or twist their torsos to access the patient. These postures put significant strain on the spine, muscles, & joints, leading to fatigue & potential injuries.

While individual variations and treatment specific contexts require further consideration, this comparison highlights the potential benefits of prioritizing upright positions whenever feasible to promote user comfort, safety, and well-being in various settings.

Conclusion

This paper has explored the potential benefits and limitations of upright therapy, aiming to present a balanced human factors perspective. While supine therapy has established its role in various clinical settings, its limitations, particularly regarding postural adaptations and physiological responses, have been highlighted. The emerging trends suggest that upright therapy might offer promising solutions to address these drawbacks. However, it is important to acknowledge that further research is crucial to fully understand the long-term efficacy and safety of upright therapy across different patient populations and conditions. Future studies should investigate the optimal protocols, dosage, and potential contraindications for this approach. Additionally, exploring the underlying mechanisms by which upright therapy exerts its effects would provide valuable insights for optimizing treatment strategies.

In conclusion, while the current evidence offers a glimpse into the potential of upright therapy, further research is necessary to solidify its role in clinical practice. By continuing to investigate this avenue, more comprehensive and effective treatment approaches can be developed for various conditions.

Limitations

The sample size of the patient and clinician groups involved in the workshop may not be fully representative of the broader population. REBA analysis relies on self-reported information, which might introduce some bias. The review of benefits relied on the quality and availability of existing studies, which may not encompass all relevant research.

Despite these limitations, the combined methodology employed in this research provides a comprehensive initial assessment of the potential advantages of upright therapy for various stakeholders, including patients, clinicians, and healthcare institutions.

Disclaimer

This research was conducted independently and not based on any endorsement or affiliation with any particular manufacturer or company. The selection of the supine device or the upright patient positioning system for this research was based solely on accessibility of information and system.

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