Research Article

Time estimation is associated with the levels of distress in patients prior to starting radiotherapy

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ABSTRACT

Purpose or Objective: The aim of this study was to explore the potential relationship between the time estimation and psychological distress in patients with solid tumors prior to starting radiotherapy.

Materials and Methods: In this multicenter study were included a total of 344 patients with solid tumors (197 with and 147 without metastatic disease). The time estimation was assessed by evaluating each subjects prospective estimation of how fast 1 min passed compared to the actual time. The median value (35sec) of subjective perception of time was used to group cases into two categories for experience of time. We used the National Comprehensive Cancer Network Distress Thermometer at the beginning of treatment to determine the levels of distress, where it measures distress on a scale from 0 to 10. Patients scoring 4 or above (73.5 %) were regarded as having high levels of distress.

Results: The time estimation distributions significantly changed according to the level of distress. ROC analysis revealed that at the optimal cut off value of time estimation, patients with low and high distress levels can be discriminated with an AUC = 0.80 (95 % CI: 0.75– 0.85, $p < 0.001$) and with a sensitivity of 77.8 % and specificity of 73.3 %. In a multivariate logistic regression model, fast time estimation was an independent predictor of high levels of distress (OR 0.136; 95 % CI, 0.072——0.256, $p < 0.001$).

Conclusion: Time estimation is a novel potent indicator of high levels of distress in cancer patients prior starting of radiotherapy.

Introduction

The National Comprehensive Cancer Network (NCCN) formed a multidisciplinary panel to investigate the integration of psychological therapy into cancer treatment. Cancer has been recognized as having a significant impact on a patient's family, social relationships, financial situation, and professional life [1–3]. Distress encompasses a spectrum of emotions, spanning from typical sensations of dread, grief, and vulnerability to severe issues like panic, anxiety, depression, social isolation, and existential and spiritual crises. According to current guidelines, it is recommended that all patients undergo screening for distress during their first visit and as necessary based on changes in their illness state [4].

The level of discomfort can be quantified using the distress thermometer (DT), typically administered in conjunction with a problem list. The clinical utility of the DT has been investigated in patients with different forms of cancer, and this assessment has shown high precision in identifying distress [5–8]. The DT deemed a score of ≥ 4 as adequate to prompt further inquiry and potential referral to psychological care. This questionnaire offers a rapid means to assess patients for distress and other psychosocial issues.

Approximately a third of cancer patients are estimated to experience a significant degree of distress, which varies by cancer site [5]. Elevated levels of distress have been demonstrated to be an unfavorable prognosis

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indicator. However, these heightened levels of concern can also trigger or worsen symptoms such as decreased appetite, impaired concentration, and insomnia. A study discovered that individuals with elevated distress levels, both before and during radiotherapy (RT), have a worse chance of survival [9].

People experience the perception of time passing at varying rates, with some perceiving an hour to elapse rapidly, while a few minutes may feel prolonged. There is a significant correlation between an individual's emotional state and their perception of time. Engaging in interesting activities can make time appear to pass quickly, whereas experiencing boredom during monotonous situations can make time feel subjectively slower [10–12]. Prospective time estimate is influenced by cognitive models that propose an individual's experience of time is reliant on an internal clock, which generates subjective time units [11,13]. There are multiple studies available on correlation between the perception of time and emotional suffering in individuals with cancer, but there is a lack of organized and comprehensive data on this matter.

The aim of our study was to investigate the potential correlation between the perception of time and the level of distress in cancer patients prior to starting radiotherapy. Patients' thoughts are consumed with their sickness and symptoms, cancer therapy, side effects, and the fear of death. It is hypothesized that stressful thoughts divert attention from time, resulting in a reduced perception of subjective time units. Our hypothesis posits that patients with fast time estimation exhibit elevated levels of distress.

Materials and methods

Patient selection

This Bulgarian multicenter study was conducted in six Radiotherapy departments which were similar in treatment availability, with different geographical location in the country and included 344 patients who were treated in the period August 2022 – October 2023. The including criteria were as follows: histologically verified cancer, treatment with radiotherapy, age greater than 18 years, the absence of psychiatric disorders, and the absence of clinical conditions that could impede the patient's understanding of the provided materials and assignments constituted. Basic sociodemographic and clinicopathological data were collected, along with an assessment of distress and time estimation. The procedure was approved by the Scientific Research Ethics Committee of the institution.

Assessment of distress

In accordance with the NCCN guidelines, we chose the DT as a distress screening instrument. The DT is a validated self-reported tool that allows rapid screening. The patient is asked to indicate a number on a visual-analog scale that represents his or her psychological condition prior to starting radiotherapy. The scale ranges from 0 (no distress) to 10 (extreme distress) [14]. A meta-analysis of 42 cancer studies found that the pooled sensitivity of DT is 81 % and that the pooled specificity is 72 % at a cutoff score of 4 [5]. The subjects were divided into two groups according to their DT scores: high distress (scores 5–10) and low distress (scores 0–4).

Measurement of time estimation

The individuals' time estimation was evaluated based on their unique prospective estimation of the relative speed at which 1 min elapsed compared to the actual time. The patient was instructed to approximate a length of 1 min following the initiation signal. Upon receiving a stop signal from the subject, the investigator promptly halted the clock and documented the anticipated time. The patients were stratified into two categories, fast (≤median) and slow (>median) time, based on the median value of time estimation (35 s).

Statistical design and analysis

Data were managed and analyzed using IBM SPSS Statistics software ver. 23. The Mann-Whitney U test, $\chi2$ test, and Spearman correlation were used to compare and evaluate the correlations between the level of distress and clinicopathological characteristics of the patients, such as age, gender, primary tumor location, tumor stage and experience of time. For the interpretation of correlation test results, rho values were interpreted as follows, < 0.19, very weak; 0.19–0.39, weak; 0.40–0.59, moderate; 0.60–0.79, strong; and ≥ 0.80, very strong. The diagnostic accuracy of subjective time estimation was also determined by obtaining the largest possible area under the curve (AUC) in receiver operating characteristic curve (ROC) analysis. AUC values ≥ 0.9 are considered excellent, ≥ 0.80 good, ≥ 0.70 fair, and < 0.70 poor. Odds ratios (ORs) with confidence intervals (CIs) for categorical outcomes were calculated using a binary logistic regression model. A p value < 0.05 (two-tailed) was considered significant.

Results

Patient characteristics

A total of 344 patients with malignant solid tumors participated in the study; 179 (52 %) were men, and 165 (48 %) were women. The median age was 63 years, and the mean age of the group was 61.7 ± 11.21 years, with an age range of 30 to 89 years. The sample included subjects with nine varieties of cancer types, representing more than 20 different histology types of patients with other cancers. For our patients, the estimated duration of 1 min varied between 8 and 73 s.

Correlation between time estimate, level of distress and patient characteristics

The mean distress score was 5.0 ± 2.2. A total of 191 (55.52 %) patients had high distress, and their mean distress score was 6.8 ± 1.9. A fast time estimation, gender, tumor stage and cancer type were correlated with high levels of distress (p < 0.001). (Table 1.) Women (5.97 ± 1.89) had significantly higher levels of distress than men (4.10 ± 2.13) (p < 0.001). Patients treated with palliative radiotherapy (5.76 ± 2.11) had also significantly higher levels of distress than patients treated with definitive (4.14 ± 2.31), adjuvant (4.70 ± 2.02) and neoadjuvant radiotherapy (3.87 ± 1.66) (p < 0.001). No significant differences in the levels of distress were observed with respect to age and distance travel to the treatment center.

A fast time estimation correlated with patients' level of distress (p < 0.001), treatment method (p < 0.001) and gender (p = 0.002). No significant differences in time estimation were observed with respect to age and distance travel to the treatment center. Women exhibited a trend towards a faster time estimation (31.70 ± 13.17 s) than men (36.83 ± 12.62 s) (p = 0.002). Patients on palliative radiotherapy (27.11 ± 9.40) exhibited a trend towards a faster time estimation than patients treated with definitive (39.11 ± 13.49), adjuvant (40.23 ± 12.27) and neoadjuvant radiotherapy (45.43 ± 10.94) (p < 0.001). Patients with a fast time estimation had significantly higher levels of distress (6.10 ± 2.07) than patients with a slow time estimation (3.90 ± 1.79) (p < 0.001). (Fig. 1).

ROC analysis revealed that at the optimal cutoff value of time estimation, patients with low and high distress levels can be discriminated with an AUC = 0.80 (95 % CI: 0.75– 0.85, p < 0.001) and with a sensitivity of 77.8 % and specificity of 73.3 %. (Fig. 2) A negative correlation was observed between pre-treatment time estimation and levels of distress (Spearman rho = -0.55, p < 0.0001).

Predictors of high levels of distress

In univariate logistic regression analysis, patients with a fast time

Table 1
Correlations between level of distress and patient characteristics.

Characteristics	Low distress	High distress	p-value
Gender			<0.001
Men	115 (33.4 %)	64 (18.6 %)	
Women	38 (11.1 %)	127 (36.9 %)	
Age			0.538
<63 y.	76 (22.1 %)	95 (27.6 %)	
≥63 y.	77 (22.4 %)	96 (27.9 %)	
Cancer type			<0.001
Prostate	21 (6.1 %)	10 (2.9 %)	
HNC	38 (11.0 %)	14 (4.1 %)	
Lung	20 (5.9 %)	38 (11.0 %)	
Glioblastoma	3 (0.9 %)	7 (2.0 %)	
Gynecologic	6 (1.7 %)	28 (8.1 %)	
Breast	17 (4.9 %)	51 (14.8 %)	
GI	31 (9.0 %)	29 (8.4 %)	
Urothelial	11 (3.3 %)	11 (3.3 %)	
Melanoma	6 (1.7 %)	3 (0.9 %)	
Stage			<0.001
I	9 (2.6 %)	15 (4.4 %)	
II	19 (5.5 %)	25 (7.3 %)	
III	60 (17.4 %)	19 (5.5 %)	
IV	65 (18.9 %)	132 (38.4 %)	
Radiotherapy			<0.001
Definitive	51 (14.8 %)	27 (7.9 %)	
Adjuvant	40 (11.6 %)	47 (13.7 %)	
Neoadjuvant	20 (5.8 %)	3 (0.9 %)	
Palliative	42 (12.2 %)	114 (33.1 %)	
Distance travel to treatment			0.440
<130 km	63 (18.3 %)	76 (22.1 %)	
≥130 km	90 (26.2 %)	115 (33.4 %)	
Time estimation			<0.001
Fast time estimation	33 (9.6 %)	139 (40.4 %)	
Slow time estimation	120 (34.9 %)	52 (15.1 %)	

Fig. 1. The Mann-Whitney *U* test was used to detect significant differences in the level of distress between the groups, and p < 0.05 (two-tailed) was considered to indicate significance. A bar graph depicting the level of distress in patients with slow and fast time estimations.

estimation, on palliative radiotherapy, metastatic stage and women were associated with high levels of distress. In a stepwise backward multivariate logistic regression model fast time estimation and gender were independent predictors of high levels of distress. (Table 2).

Discussion

This study aimed to examine the correlation between the perception of time and the level of distress in cancer patients prior to starting radiotherapy. Patients with distress levels ≥ 4 had faster time
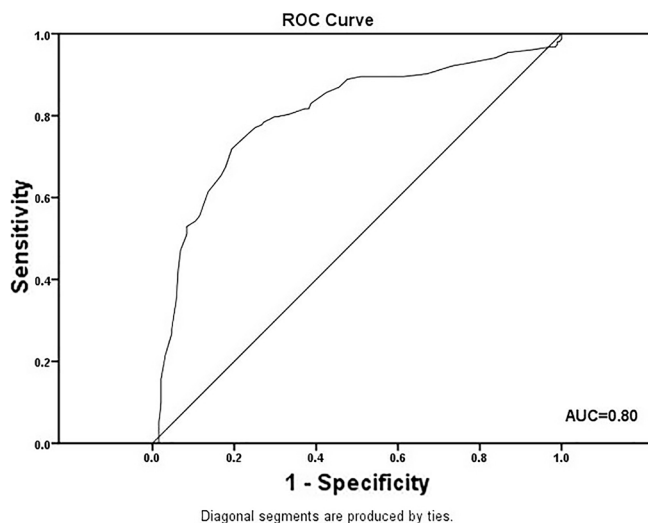

Fig. 2. Receiver operating characteristic curve (ROC) analysis in which time estimation was used to differentiate between patients with low and high levels of distress. The diagnostic accuracy of time estimation was determined by obtaining the largest possible area under the curve (AUC) in ROC analysis.

estimation, as assessed by DT. The time estimate test identified that patients with a time estimation of 35 s or less were at a higher risk of experiencing significant distress. A cancer diagnosis can have deleterious impacts on both physical and mental well-being. A diagnosis of this nature can have an adverse impact on one's ability to interact socially and undoubtedly lead to emotional suffering throughout the progression of the illness.

According to a *meta*-analysis, 30–40 % of hospitalized patients can experience a mix of mental disorders [15]. Multiple surveys revealed that a significant proportion of patients, ranging up to 52 %, exhibited moderate to severe levels of distress [16,17]. Research evidence indicated that the primary risk factors associated with distress included gender, age, marital status, disease stage, social level, and cancer type [18–20]. We found that patients who were treated with palliative radiotherapy, or women were more prone to experiencing elevated levels of distress. Our findings indicated that patients who had expectations of receiving palliative or definitive radiotherapy did differentiate between the stages of metastatic and nonmetastatic diseases and had different levels of distress. These findings indicate that the oncologist should offer additional details and explanations on the patients' stage and related outcomes to reduce their levels of discomfort.

A study demonstrated that cancer patients do not benefit from estimating and dwelling on the past [21]. These patients often exaggerated the duration of this period, leading to heightened levels of distress. Those who had positive outlooks on the future experienced a correlation between their life review and reduced distress. The study revealed that patients with advanced cancer perceive the passage of time differently compared to individuals without any signs of disease.

Various factors, including physiological state, personality, and activity during the test period, have an impact on time perception. The estimations of longer time intervals are highly varied and lack precision [22]. People tend to overestimate short periods of time, such as seconds, and underestimate longer periods, such as hours [23]. Time estimation is enhanced under experimental conditions, such as our experimental configuration where participants were required to make time judgments [24]. We evaluate time perception by a prospective estimation of a 1-minute interval. This method is both straightforward and efficient and this approach guarantees enhanced adherence from both the patient and the physician while circumventing the emotions that are necessarily associated with personal history or future.

According to multiple research projects, distress has been regarded
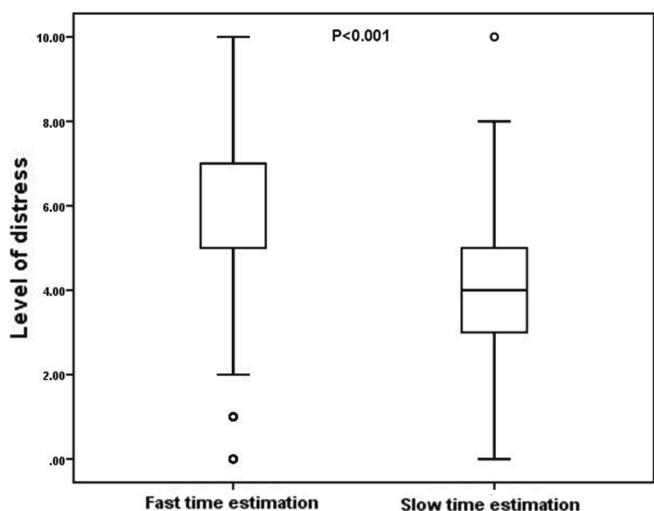
Table 2

Univariate and multivariate regression analyses for predicting high distress levels.

Variable	Univariate analysis			Multivariate analysis		
	Odd	95 % Cl	p	Odd	95 % Cl	P
Gender						
Men vs. Women	6.005	3.738–9.648	<0.001	9.781	5.138–18.377	<0.001
Age						
<63y. vs. ≥ 63y.	0.997	0.652–1.526	0.990			
Cancer type						
Melanoma	1	Reference				
Prostate	1,050	0.217–5.084	0.952			
HNC	1.357	0.298–6.176	0.639			
Lung	0.263	0.059–1.165	0.079			
Glioblastoma	0.214	0.031–1.486	0.119			
Gynecological	0.107	0.021–0.554	0.008			
Breast	0.167	0.038–0.740	0.018			
GI	0.534	0.122–2.337	0.405			
Urothelial	0.500	0.099–2.522	0.410			
Stage						
I + II + III vs. IV	3.029	1.943–4.721	<0.001	1.977	0.781–5.005	0.150
Radiotherapy						
Definitive, Adjuvant, Neoadjuvant, Palliative	3.913	2.475–6.185	<0.001	1.557	0.613–3.954	0.352
Kilometer						
<130 vs. ≥ 130	1.059	0.687–1.633	0.795			
Time						
Fast time estimation vs. Slow time estimation	0.103	0.062–0.170	<0.001	0.136	0.072–0.256	<0.001

as the sixth crucial indicator in cancer care, following pulse, blood pressure, respiratory rate, temperature, and pain [25]. The introduction of distress screening resulted in a need for a suitable tool or instrument to fulfill this objective. The tool must possess the qualities of reliability, affordability, and ease of administration. The tool should be concise and enable quick identification of individuals who may require further or more comprehensive assessment for use in everyday practice. We suggest that predicting distress among cancer patients can be done advanced by estimating a 1-minute time interval. The practicality of our suggested method lies in its ability to rapidly assess distress levels in cancer patients. The completion rate of several questions ranges from 49 % to 97.5 % [7,26]. Oncologists often fail to identify stressed individuals due to different factors [27]. Systematic reviews of screening measures for distress have highlighted the need to address issues such as variations in the ideas being measured, definitions of words, time of estimate, and the length and format of the tools [23]. There is a want for a straightforward screening tool that can be utilized in the fast-paced environment of routine clinical practice. By utilizing our proposed method, physicians can readily identify individuals at risk for significant distress by evaluating the time estimation.

In our study the AUC in ROC analysis was 0.8, which suggests good discrimination between patients with high and low distress levels. In clinical practice, many of the currently available psychological test tools and inventories produce AUCs in the 0.7–0.8 range [28,29]. When questionnaires deliver AUCs greater than 0.90, the outcome is presumed to be due to design [30]. The limitation of our study is that we did not include healthy subjects as a control group. It is believed that perception of time speeds up with age in healthy people [31]. Our results did not show a significant difference in time estimation according to patient age.

Our study revealed for the first time that an association between time estimation (assessed by the prospective estimation of a 1-min interval) and level of distress exists among patients with solid tumors prior to starting radiotherapy. Distress is a risk factor to treatment and may even negatively impact survival [25]. Early identification of significant distress is crucial to improving cancer management plan. This is an easily performed, time-saving and nonintrusive ultrashort screening tool that is even suitable for patients who are not willing to reveal their level of distress via direct questionnaires.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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