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Screening older cancer patients for a Comprehensive Geriatric Assessment: A comparison of three instruments

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Abstract

Background—The Vulnerable Elders Survey (VES-13) has been validated for screening older cancer patients for a Comprehensive Geriatric Assessment (CGA). To identify a widely acceptable approach that encourages oncologists to screen older cancer patients for a CGA, we examined the Eastern Cooperative Oncology Group Performance Status (ECOG-PS) and Karnofsky Index of Performance Status (KPS) scales' ability to identify abnormalities on a CGA and compared the performance of the two instruments with the VES-13.

Methods—We enrolled 117 participants, ≥65 years with stage I–IV cancer into this cross-sectional study. Our primary outcome variable was ≥two abnormalities on the CGA, (Yes or No). We employed receiver operating characteristic curve analysis to compare the discriminatory abilities of the three instruments to identify ≥two abnormalities on the CGA.

Results—Of the 117 participants, 43% had ≥two abnormalities on the CGA. The VES-13 was predictive of ≥two abnormalities on the CGA, area under the curve (AUC)=0.85 [(95% CI: 0.78–0.92); sensitivity=88%, specificity=69%, at cut-off ≥3]. The ECOG-PS and KPS showed similar discriminatory powers, AUC=0.88 [(95% CI: 0.83–0.94); sensitivity=94%, specificity=55%, at cut-off ≥1]; and AUC=0.90 [(95% CI: 0.84–0.96); sensitivity=78%, specificity=91%, at cut-off ≤80%], respectively.

Conclusion—The ECOG-PS and KPS were equivalent to the VES-13 in identifying older cancer patients with at least two abnormalities on the CGA. Given that oncologists are already conversant with the KPS and ECOG-PS, these two instruments offer medical oncologists a widely acceptable approach for screening older patients for a CGA.

Keywords

Older; Cancer; Comprehensive Geriatric Assessment; Screening; VES-13; KPS; ECOG-PS

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Disclosure

None of the authors have any actual or potential conflict of interest to report.

Author Contribution

Cynthia Owusu: conception and design, data collection, analysis and interpretation of data, manuscript writing; Siran Koroukian: analysis and interpretation of data, manuscript writing; Mark Schluchter: analysis and interpretation of data, manuscript writing; Paul Bakaki: analysis; and Nathan Berger: concept and design, analysis and interpretation of data, manuscript writing.

1. Introduction

Persons age 65 and older constitute the fastest growing segment of the population in America and by 2030 will account for 20% of the US population.¹ However, older adults bear a disproportionate burden of the incidence and mortality of cancer,² are more likely to receive sub-optimal therapy for their disease³ and are consistently under-represented in clinical trials.⁴ With the projected increases in the demographics of older adults it is imperative to improve cancer care to older patients.

A key approach recommended for the evaluation of older cancer patients is the Comprehensive Geriatric Assessment (CGA).⁵ The CGA is a multidisciplinary assessment that utilizes validated instruments to identify medical, psychosocial, and functional limitations of an older person in order to develop a coordinated intervention to maximize overall health with aging.⁶ The rationale for incorporating a CGA into geriatric oncology is to use the CGA to provide additional information beyond that provided by chronological age and existing oncology instruments. Indeed, emerging research studies that interface aging with cancer have demonstrated several benefits of the CGA including prediction of side effects from cancer treatment,⁷ prognosis,⁸ treatment decision-making^{9,10} and detection of geriatric problems not found by routine oncology care.^{11,12}

While highly valuable, the CGA entails administering a battery of instruments that is resource-intensive. In addition, not all older adults with cancer need a full CGA. This has fostered research efforts aimed at developing a screening instrument that can be administered quickly but at the same time has good sensitivity and specificity for capturing geriatric abnormalities. Older cancer patients who test positive on screening can then be administered the full CGA.

The Vulnerable Elders Survey (VES-13) is a 13-item self-administered instrument, validated in community dwelling elders to predict functional decline and mortality.^{13–15} The VES-13 asks older patients to report their age (65–74, 75–84, and ≥85 years); self-rated health (excellent, very good, good, fair, and poor); functional limitations (1. stooping, crouching or kneeling; 2. lifting or carrying heavy objects; 3. writing or grasping small objects; 4. walking a quarter of a mile; and 5. doing heavy housework); and functional disabilities (1. shopping for personal items; 2. managing money; 3. walking across a room; 4. doing light housework; and 5. bathing or showering).^{13,15,16} Scores ≥3 are associated with increased risk of functional decline and mortality.^{13–15} The VES-13 has been recommended by the National Comprehensive Cancer Network (NCCN) as appropriate for screening older cancer patients for a full CGA⁵ and has recently been validated for this purpose.^{17,18}

To provide medical oncologists with a widely acceptable screening instrument for identifying older cancer patients who might benefit from a CGA, we examined the discriminating abilities of the Eastern Cooperative Oncology Group Performance Status (ECOG-PS) and Karnofsky Index of Performance Status (KPS) scales to identify patients with abnormalities on the CGA. The ECOG-PS is widely used in oncology to assess performance status and scores correlated with survival,¹⁹ tolerance to treatment,²⁰ comorbidity,²¹ quality-of-life²² and components of the CGA.⁸ Assigned scores range from 0 for best functional status to 4 for worst functional status. The KPS is also widely used in oncology as a measure of functional status,²³ cancer treatment outcome,²⁴ survival²⁵ and quality-of-life.²⁶ Assigned scores range from 100% for best functional status to 0% for worst functional status. The ECOG-PS and KPS show excellent correlation and inter-conversion.^{27,28}

We hypothesized that because functional assessment is a key domain of the CGA and both the ECOG-PS and KPS were functional assessment instruments, the ECOG-PS and KPS

would adequately identify patients needing a full CGA. We also compared the screening abilities of the ECOG-PS and KPS with the VES-13 because the VES-13 is currently the only validated instrument for screening for a CGA in geriatric oncology.^{17,18}

2. Patients and Methods

2.1. Study Design and Patient Population

This is a baseline cross-sectional study. A convenience sample of patients ≥ 65 years of age with histologically confirmed new cancer diagnosis, irrespective of stage, who sought care at ambulatory oncology clinics at an academic center were recruited between February 1, 2008 and July 31, 2009. Patients who were non-English speaking were excluded since the study relied heavily on instruments mostly validated in English. A total of 121 patients were enrolled of which 117 completed study assessments at baseline. Of the four patients who did not complete baseline assessments, two died before the baseline assessment could be completed, one withdrew from the study, and another was lost to follow-up. There were no significant differences in baseline characteristics between patients who completed the baseline assessment and those who did not. The study was approved by the Institutional Review Board.

2.2. Study Procedures, Measures and Data Collection

Eligible patients were approached for informed consent by a research assistant during patients' initial visit with a medical or radiation oncologist. With the exception of the VES-13 which was patient self-administered, all consenting patients completed an assessment administered by a research assistant who was unaware of the study's aim and hypothesis. Captured data included: 1) socio-demographic variables (age, gender, race/ethnicity, educational, marital and employment status, living arrangement and health insurance coverage); 2) VES-13, ECOG-PS and KPS scores; and 3) other geriatric assessment variables. All assessments were completed prior to receipt of any systemic cancer treatment or radiation therapy. Medical record abstraction was also conducted by a research assistant to collect data on tumor characteristics and cancer treatment.

2.3. Instrumentation

Instruments used for the CGA are described below.

2.3.1. Functional Assessment—*The Katz Activities of Daily Living (ADLs)* are necessary skills for basic living and measure self-reported dependence or non-dependence with bathing, transfer, dressing, continence, toileting and feeding.²⁹ *The Lawton's Instrumental Activities of Daily Living (IADLs)* are the skills required for living independently in the community and measure dependence or non-dependence with shopping, using the telephone, managing medications, housekeeping, laundry, transportation, ability to manage finances, and preparing meals.³⁰ Scores of less than the maximum, six and eight points on the ADL and IADL, respectively, denote dependency.

The *Falls Risk Assessment* was based on a self-report of at least two falls in the last six months³¹ and/or taking >14.5 s to complete the "Timed-Up-and-Go" (TUG) test.³² The TUG requires participants to stand up from a chair, walk 3 m (10 ft), turn, walk back, and sit down. Time taken to complete the test correlates strongly with falls (cut-off: >14.5 s).³²

2.4. Comorbidities

We ascertained from medical records and self-report each participant's comorbidities at study entry and used this information to calculate the *Charlson Comorbidity Index (CCI)*,³³

based on the presence or absence of 18 conditions. The CCI was chosen for its validity in breast cancer research and wide applicability.³³ The final score was provided by the sum of predefined weight for each condition.

Cognitive status was evaluated with the *Mini-Mental State Examination (MMSE)* which tests orientation, recall, attention, calculation, language manipulation, and constructional praxis. The MMSE has wide applicability.³⁴ A score of less than 24 out of 30 points is suggestive of dementia.³⁵

Psychological state was assessed with the *Geriatric Depression Scale*, a 15-item self-report assessment with good psychometric properties used to identify depression in the elderly.³⁶ Scores >5 indicate depression.

Medication review entailed recording details of all medications participants were taking by relying on participant self-report and medical records. Using the medication count we defined excessive polypharmacy^{37,38} as the concurrent use of ten or more prescribed medications. The concurrent use of ten or more medications has been associated with increased risk of hip fractures³⁹ and mortality³⁸ in older adults.

Visual and hearing impairment were ascertained using a five-point Likert scale question which asked participants the following questions, “how is your eyesight?” and “how is your hearing?”, respectively. Participants responding poor/totally blind or poor/totally deaf were considered visually or hearing impaired, respectively.

The *Medical Outcomes Study Social Support Survey*⁴⁰ was used to measure perceived social support based on 19 items on a 5-point Likert scale. Scores were transformed on a scale of 0–100. Higher scores indicated more support. Participants scoring in the lowest quartile were assigned to the “inadequate social support” group.

2.5. Analytic Variables

2.5.1. Primary Outcome Variable—The primary outcome variable was defined as the presence of $\geq$ two abnormalities on the CGA, (*Yes* or *No*).^{6,17} Geriatric abnormalities consisted of ADL and IADL disability, multiple comorbidities, cognitive impairment, depression, excessive polypharmacy, increased risk of falls, visual and hearing impairment and inadequate social support.

2.5.2. Independent Variables—Independent variables included VES-13, KPS and ECOG-PS scores, analyzed as continuous variables and also categorized as follows: VES-13 scores, (0–2, 3–6, 7–10); KPS, (100%, 90%, $\leq$ 80%), and ECOG-PS, (0, 1, $\geq$ 2).

2.5.3. Other Variables—Other variables included age (65–74, $\geq$ 75); sex; race (African-American, other); marital status (married, other); educational status ($\leq$ high school, more than high school); living situation (alone, other); employment (retired, other); health insurance (Medicare, other); CCI (0, 1, $\geq$ 2); tumor site (breast, other); stage (I–II, III–IV); and surgery (Yes/No).

2.6. Data Analysis

We conducted descriptive analysis to examine participants’ baseline characteristics and bivariate analysis to examine the distribution of baseline characteristics by our primary outcome. To compare the discriminatory power of the VES-13, KPS and ECOG-PS (*test instruments*) for identifying $\geq$ two geriatric abnormalities on the CGA (gold standard instrument), logistic regression receiver operating characteristics (ROC) curve were calculated for the test instruments, using estimated area under the ROC curve with 95%

confidence interval as an index of predictive accuracy. ROC curve areas of different models were compared using the method of Delong and Delong.⁴¹ To reduce the Type 1 error rate associated with pair-wise comparisons p-value <0.01 were considered significant. Optimal cut-off scores for the instruments that minimize cost were determined as the cut-offs maximizing the quantity $J = \text{SEc} + R * \text{SPc}$, where SEc and SPc are sensitivity and specificity, respectively, at a chosen cut-point and $R = (1 - \pi) / (a\pi)$, where π is the prevalence of $\geq$ two geriatric abnormalities and a is the relative cost of a false negative as compared with a false positive.⁴² AUCs were categorized into ≥ 0.8 , <0.8 to ≥ 0.7 , and <0.7 to represent excellent, moderate or poor instrument discriminating ability, respectively. Similar logistic regression ROC analyses were conducted to compare the discriminating abilities of the three test instruments to predict individual geriatric abnormalities. Predictive probabilities for $\geq$ two geriatric abnormalities were generated. All analyses were conducted using SAS version 9.1 (SAS institute, Cary, NC).

3. Results

3.1. Baseline Characteristics

Participants' baseline characteristics are presented in Table 1. One hundred and seventeen participants were evaluable and were included in the analyses. The median age was 73 years, (inter-quartile range: 69 to 80 years). The study population consisted predominantly of white Medicare-insured patients, about half of whom had more than a high school education (45%), were other than married (63%) and lived alone (41%). Most patients had breast cancer (59%), stage I–II disease (59%) and underwent surgery (69%).

3.2. Prevalence of Geriatric Abnormalities

A majority (75%) had at least one geriatric abnormality and 43% had $\geq$ two geriatric abnormalities on the CGA. The median number of geriatric abnormalities for the entire cohort was one, (inter-quartile range: 0 to 3). The prevalence of individual geriatric abnormalities was as follows: ADL disability (19%), IADL disability (45%), multiple comorbidities (36%), dementia (6%), depression (12%), recurrent falls/increased risk of falls (23%), excessive polypharmacy (9%), visual impairment (9%), hearing impairment (4%) and inadequate social support (27%). Participants with $\geq$ two geriatric abnormalities on the CGA compared with those with less than two geriatric abnormalities on the CGA were more likely to be ≥ 75 years (63% vs. 37%, $p=0.003$); African-American (62% vs. 38%, $p=0.04$); male (67% vs. 33%, $p=0.06$); have $\leq$ a high school education (58% vs. 42%, $p=0.007$); have stage III–IV disease (57% vs. 43%, $p=0.05$); unemployed (0% vs. 100%, $p=0.01$); score ≥ 3 on the VES-13 (68% vs. 32%, $p<0.0001$); score ≥ 1 on the ECOG-PS (61% vs. 39%, $p<0.0001$); score ≤ 80 on the KPS (87% vs. 13%, $p<0.0001$); have other than breast cancer (60% vs. 40%, $p=0.02$); and not to have received primary surgery (77% vs. 23%, $p<0.0002$). These results are not shown.

3.3. Discriminatory Abilities of the VES-13, ECOG and KPS

The VES-13, ECOG-PS and KPS were equivalent in identifying $\geq$ two geriatric abnormalities on the CGA, (see Table 2 and Fig. 1). The VES-13 was predictive of $\geq$ two geriatric abnormalities, AUC=0.85 (95% CI: 0.78–0.92), sensitivity of 88% and specificity of 69% at cut-off ≥ 3 . With each one-unit increase in VES-13 scores, the odds of having $\geq$ two geriatric abnormalities increased by 78% (OR=1.78, 95% CI: 1.43–2.21). The ECOG-PS showed similar discriminatory powers, AUC=0.88 (95% CI: 0.83–0.94), sensitivity of 94%, specificity of 55% at cut-off ≥ 1 . With each one-unit increase in ECOG scores, the odds of having $\geq$ two geriatric abnormalities increased by almost fifteen-fold (OR=14.73, 95% CI: 5.42–39.99). The KPS also demonstrated similar discriminatory abilities, AUC=0.90 (95% CI: 0.84–0.96), sensitivity of 78%, specificity of 91% at cut-off ≤ 80 .

With each 10% increase in KPS scores, the odds of having $\geq$ two geriatric abnormalities decreased by 85% (OR=0.15, 95% CI: 0.07–0.28). Using the observed prevalence of 0.43 (proportion with $\geq$ two abnormalities on the CGA), and considering a cost ratio $a=2$ (where the cost of a false negative is twice that of a false positive), the optimal cut-off values were as follows: VES-13: ≥ 3 ; ECOG-PS: ≥ 1 ; KPS: $\leq 80\%$, (see Table 2). Pair-wise comparisons between the VES-13 vs. ECOG-PS, VES-13 vs. KPS, and ECOG-PS vs. KPS showed no significant difference between ROC curves, [difference=−0.03, p-value=0.34, (95% CI: −0.11–0.04); difference=−0.05, p-value=0.17, (95% CI: −0.12–0.02); difference=−0.01, p-value=0.29, (95% CI: −0.04–0.01), respectively]. The predictive probabilities for $\geq$ two geriatric abnormalities demonstrated by all three instruments were remarkable with rapidly increasing probabilities for VES-13 scores (3 to 7), ECOG-PS (1 to 2) and KPS (70% to 90%), (see Fig. 2).

Generally, all three instruments demonstrated comparable discriminatory abilities for identifying individual geriatric abnormalities. The VES-13, ECOG-PS and KPS demonstrated excellent discriminatory abilities for identifying ADL and IADL disability and cognitive impairments. All three instruments demonstrated moderate discriminatory abilities for identifying multiple comorbidities, excessive polypharmacy, falls, and visual impairment and poor discriminating abilities for identifying depression, hearing impairment, and inadequate social support. The only statistical difference in instrument performance was in relation to ADL disability, where although excellent performance was demonstrated by all three instruments, the KPS out-performed the VES-13, see Table 3.

4. Discussion

Among patients ≥ 65 years of age with newly diagnosed cancer, a high prevalence of geriatric abnormalities was found with 43% of the population having $\geq$ two geriatric abnormalities. The ECOG-PS and KPS performed equally well as the VES-13 in identifying older cancer patients with $\geq$ two abnormalities on the CGA. Therefore, all three instruments can be used as screening instruments for identifying older cancer patients needing a full Comprehensive Geriatric Assessment.

There is a dearth of existing literature on appropriate screening instruments for identifying older cancer patients for a CGA. The first study, conducted by Mohile et al.¹⁷ in 2007, examined the utility of the VES-13 for identifying geriatric impairments among 50 prostate cancer patients ≥ 70 years of age. Their study demonstrated excellent predictive ability of the VES-13 for identifying $\geq$ two geriatric impairments on the CGA; (AUC=0.90, sensitivity of 72.7%, specificity of 85.7% at a cut-off of 3). More recently, Luciani et al.¹⁸ in a much larger study of 412 older cancer patients, reported consistent predictive ability of the VES-13 for identifying patients with “abnormalities” on the CGA; (AUC=0.83, sensitivity of 87% and specificity of 62% at a cut-off of 3). To the best of our knowledge our study is the first to compare existing oncology instruments to the VES-13 as screening instruments for identifying older cancer patients needing a CGA.

Most cancer patients will be ≥ 65 years of age at initial diagnosis. Given that there are very few trained geriatric-oncologists in the US, a larger proportion of vulnerable older patients with cancer will be seen by medical oncologists and are unlikely to undergo a CGA. Barriers include, but are not limited to, a lack of familiarity with geriatric assessment instruments. This has served to dampen the enthusiasm of oncologists for obtaining a CGA for their vulnerable patients or making the appropriate referral to a geriatric-oncologist or a geriatrician for a CGA. Our study, by demonstrating an equivalent excellent discriminatory ability of both the ECOG-PS and KPS in comparison to the VES-13 for identifying patients needing a CGA, takes advantage of instruments medical oncologists have already been

trained to use, obviating the need to re-train medical oncologists to administer geriatric screening instruments, which by itself presents another barrier.

Traditionally, the cut-offs for the ECOG-PS and KPS for identifying patients at increased risk for chemotherapy toxicity and for excluding patient participation in most clinical trials have been at ≥ 2 and $\leq 70\%$, respectively.^{29,43} However, our study results suggest that the cut-offs for completing CGAs ought to be ≥ 1 for the ECOG-PS and $\leq 80\%$ for the KPS. At the traditional cut-offs patients' poor health status are readily apparent and one does not need a screening instrument to determine the need for a CGA. However, if we are to realize our overarching goal of improving cancer outcomes for older adults, identification of the "vulnerable" older cancer patient with less overt signs of poor health status will be critical. Completing a CGA for older cancer patients with ECOG-PS ≥ 1 and KPS $\leq 80\%$ will identify patients with geriatric abnormalities that are not so readily apparent and may help to prevent adverse complications associated with cancer treatment.

Strikingly, our study showed a very high prevalence of geriatric abnormalities. Our findings are consistent with studies by Mohile et al.¹⁷ and Kellen et al.⁴⁴ whose respective studies showed 60% and 68% of older cancer patients had ≥ 2 geriatric abnormalities upon completion of a CGA. These findings are in contrast with the general geriatric population where prevalence rates of 49% for "geriatric syndromes" have been reported.⁴⁵ Indeed, Mohile et al.,⁴⁶ in another study demonstrated that geriatric syndromes were more prevalent in cancer survivors than non-cancer survivors.⁴⁶ Other reasons for the difference in prevalence beyond the diagnosis of cancer include the lack of consensus definition as to which geriatric conditions constitute a "geriatric syndrome" leading to a varying range of assessments on the CGA.⁴⁵ Prevalence rates of geriatric conditions in any population will correlate positively with the number of conditions evaluated for on a CGA. Our study examined for ten geriatric-related abnormalities. Therefore, it is not surprising that 73% of our patient population would have at least one geriatric abnormality.

The identified socio-demographic and clinical correlates of the co-occurrence of geriatric abnormalities in this older cancer population are note-worthy. Our study identified several sub-cohorts of older cancer patients, including older African Americans, who were more likely to have multiple geriatric abnormalities at the time of initial cancer diagnosis. Efforts targeted at those at increased risk for the co-occurrence of geriatric abnormalities should in the long-term contribute to improving cancer outcomes for older adults.

Our study has several limitations. First the ECOG-PS, KPS and CGA were all completed by one research assistant raising the possibility that a bias could have been introduced into the study. However, the research assistant was blinded to the study's specific aim and was not aware of the outcomes of interest. In addition, the VES-13 was patient self-administered. Second, our patient population was heterogeneous and included patients with different cancer types and stages. However, this is a cross-sectional study that seeks to determine the association between scores of three test instruments and the CGA at one-point in time, baseline. The study does not seek to examine cancer, stage or treatment effect on outcomes and therefore the heterogeneity of the patient population should not introduce a bias into study results. Moreover, more than half of the patient population were breast cancer patients and one may argue that the study results may primarily be applicable to breast cancer patients in particular and not necessarily generalizable. Third, the low specificity of the VES-13 and ECOG-PS, in identifying abnormalities on the CGA deserves comment. Our primary outcome, the presence of ≥ 2 geriatric abnormalities, is more stringent and is aimed at capturing the most vulnerable. Therefore, most of the "false positive" patients actually had one geriatric abnormality (30%), as shown in Table 1. Regardless, even though Luciani et al.¹⁸ used a less stringent definition for their outcome variable in their validation study of

the VES-13, the specificity of the VES-13 obtained in their study was only 62% at a cut-off of 3. Further studies to develop the ideal screening instrument that has optimum sensitivity and specificity for identifying older cancer patients for a CGA are therefore warranted. Another caveat that applies to all three instruments is the moderate to poor discriminating abilities in identifying several geriatric problems. As such none of the three instruments are equivalent to the full CGA and all three instruments must be used for screening purposes only.

In conclusion, patients ≥ 65 years with newly diagnosed cancer and a VES-13 score of ≥ 3 , ECOG-PS score of ≥ 1 or a KPS score of $\leq 80\%$ are highly likely to have multiple abnormalities on the CGA and should be referred to a geriatric-oncologist or geriatrician for a full CGA to identify and intervene on geriatric problems that may otherwise remain undetected and will adversely impact cancer outcomes in this underserved population.

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Receiver Operating Characteristics Curves Comparing the Discriminatory Abilities of the VES-13, ECOG and KPS for Identifying Two or More Abnormalities on the CGA

Area Under the Curve and 95% CI			
Instrument	AUC	SE	95% CI
VES-13	0.85	0.04	0.78 0.92
ECOG	0.88	0.03	0.83 0.94
KPS	0.89	0.03	0.84 0.96

ROC Contrast Rows Estimation and Testing Results			
Contrast	Estimate	95% CI	P-value
VES and ECOG	-0.03	-0.11 0.04	0.34
VES and KPS	-0.05	-0.12 0.02	0.17
ECOG and KPS	-0.01	-0.04 0.01	0.29

Fig. 1.
Receiver operating characteristics curves comparing the discriminatory abilities of the VES-13, ECOG and KPS for identifying two or more abnormalities on the CGA.

Predicted Probabilities For $\geq$ Two Geriatric Abnormalities

Fig. 2.
Predicted probabilities for $\geq$ two geriatric abnormalities.

Table 1

Baseline characteristics of participants.

Characteristic	N=117 (100%)
Age group (years)	
65 to 74	65 (56%)
≥75	52 (44%)
Sex	
Female	96 (82%)
Male	21 (18%)
Race	
African-American	39 (33%)
Other	78 (67%)
Marital status	
Married	39 (35%)
Other	74 (65%)
Missing/unknown	4
Educational status	
High school or less	60 (54%)
More than high school	52 (46%)
Missing/unknown	5
Living situation	
Alone	48 (42%)
Other	65 (58%)
Missing/unknown	4
Health insurance coverage	
Medicare	103 (90%)
Other	10 (10%)
Missing/unknown	4
Tumor site	
Breast	69 (59%)
Other ^a	48 (41%)
Stage	
Stages I–II	67 (59%)
Stages III–IV	47 (41%)
Unknown	3
Receipt of primary surgery	
Yes	81 (70%)
No	35 (30%)
Unknown	1
VES-13 scores	
0–2	52 (44%)
3–6	41 (35%)

Characteristic	N=117 (100%)
7–10	24 (21%)
ECOG	
0	40 (34%)
1	44 (38%)
2–4	33 (28%)
KPS	
100	37 (32%)
90	35 (30%)
≤80	45 (38%)
ADL disability ^b	
No	95 (81%)
Yes	22 (19%)
IADL disability ^b	
No	64 (55%)
Yes	53 (45%)
Charlson comorbidity index	
0	48 (41%)
1	27 (23%)
≥2	42 (36%)
Geriatric abnormalities ^c	
0	32 (27%)
1	35 (30%)
≥2	50 (43%)

Notes to Table 1

^aOther tumor types include colon (12%), lung (9%), pancreatic cancer (4%), other GI (5%), head and neck (3%) and all others (9%).

^bADL and IADL refer to activities of daily living and instrumental activities of daily living, respectively.

^cGeriatric abnormalities include ADL and IADL dependence, multiple comorbidities, cognitive impairment, depression, excessive polypharmacy, falls, visual and hearing impairment, and inadequate social support.

Unadjusted odds ratio and receiver operating curve characteristics of the VES-13, ECOG-PS and KPS in relation to ≥ 2 geriatric abnormalities on the Comprehensive Geriatric Assessment.

Table 2

Instruments/ cut-off	Odds ratio of ≥ 2 geriatric abnormalities vs. none per unit-point increase ^a	Area under the curve	Sensitivity	Specificity	Positive predictive value	Negative predictive value	J index ^b
VES-13 cut-off score ≥ 2	1.78 (1.43, 2.21)	0.85 (0.78, 0.92)	47/50 (94%)	30/67 (45%)	47/84 (56%)	30/33 (91%)	0.237
VES-13 cut-off score ≥ 3			44/50 (88%)	46/67 (69%)	44/65 (68%)	46/52 (88%)	0.335
VES-13 cut-off score ≥ 4			31/50 (62%)	61/67 (91%)	31/37 (84%)	61/80 (76%)	0.223
ECOG cut-off score ≥ 1	14.73 (5.42, 39.99)	0.88 (0.83, 0.94)	47/50 (94%)	37/67 (55%)	47/77 (61%)	37/40 (93%)	0.306
ECOG cut-off score ≥ 2			32/50 (64%)	66/67 (99%)	32/33 (97%)	66/84 (79%)	0.293
ECOG cut-off score ≥ 3			10/50 (20%)	67/67 (100%)	10/10 (100%)	67/107 (63%)	-0.137
KPS cut-off score $\leq 90\%$	0.15 (0.07, 0.28)	0.90 (0.84, 0.96)	47/50 (94%)	34/67 (51%)	47/80 (59%)	34/37 (92%)	0.276
KPS cut-off score $\leq 80\%$			39/50 (78%)	61/67 (91%)	39/45 (87%)	61/72 (85%)	0.383
KPS cut-off score $\leq 70\%$			28/50 (56%)	67/67 (100%)	28/28 (100%)	67/89 (75%)	0.223

^aUnit-point for VES-13=1 point; unit-point for the ECOG=1 point; and unit-point for the KPS=10 points.

^bJ index (see Patients and methods) calculated based on a prevalence rate of ≥ 2 geriatric abnormalities of $\pi=0.43$ and a ratio of costs of false negative:false positive of $a=2$. The highest J index indicates the optimum cut-off.

Receiver operating characteristics of the VES-13, ECOG and KPS scores in relation to scores of individual instruments of the Comprehensive Geriatric Assessment.

Table 3

Domain/instrument	Abnormal cut-off score	% with abnormal scores	VES-13 (95% CI)	ECOG (95% CI)	KPS (95% CI)	Pair-wise comparisons
<i>Functional status:</i> activities of daily living	Dependency in ≥ 1 ADL	19%	AUC=0.81 (0.72, 0.91)	AUC=0.93 (0.88, 0.98)	AUC=0.95 (0.90, 0.99)	VES/ECOG=0.02 VES/KPS=0.006 ECOG/KPS=0.44
<i>Functional status:</i> instrumental activities of daily living	Dependency in ≥ 1 IADL	45%	AUC=0.91 (0.86, 0.96)	AUC=0.89 (0.84, 0.94)	AUC=0.93 (0.88, 0.97)	VES/ECOG=0.65 VES/KPS=0.54 ECOG/KPS=0.04
<i>Falls risk:</i> number of falls in the last six months and the "Timed-Up-and-Go" (TUG) test	≥ 2 falls in 6 months and/or taking >14 s to complete the TUG test	23%	AUC=0.78 (0.69, 0.88)	AUC=0.78 (0.67, 0.90)	AUC=0.79 (0.68, 0.91)	VES/ECOG=0.98 VES/KPS=0.82 ECOG/KPS=0.55
<i>Cognition:</i> Mini Mental State Examination	Score <24	6%	AUC=0.81 (0.63, 0.99)	AUC=0.81 (0.67, 0.96)	AUC=0.84 (0.74, 0.94)	VES/ECOG=0.92 VES/KPS=0.65 ECOG/KPS=0.51
<i>Comorbidities:</i> Charlson Comorbidity Index	Score ≥ 2	36%	AUC=0.72 (0.62, 0.81)	AUC=0.76 (0.68, 0.85)	AUC=0.77 (0.69, 0.86)	VES/ECOG=0.26 VES/KPS=0.17 ECOG/KPS=0.61
<i>Excessive polypharmacy:</i> list of medications	≥ 10 prescribed medications	9%	AUC=0.72 (0.55, 0.89)	AUC=0.76 (0.59, 0.92)	AUC=0.76 (0.59, 0.93)	VES/ECOG=0.68 VES/KPS=0.67 ECOG/KPS=0.82
<i>Vision:</i> 5-point Likert scale questionnaire	Reporting poor eye sight or being totally blind	9%	AUC=0.62 (0.40, 0.83)	AUC=0.74 (0.59, 0.89)	AUC=0.81 (0.68, 0.94)	VES/ECOG=0.29 VES/KPS=0.15 ECOG/KPS=0.13
<i>Hearing:</i> 5-point Likert scale questionnaire	Reporting poor hearing or being totally deaf	4%	AUC=0.65 (0.37, 0.94)	AUC=0.68 (0.50, 0.86)	AUC=0.72 (0.51, 0.92)	VES/ECOG=0.77 VES/KPS=0.67 ECOG/KPS=0.62
<i>Psychosocial/emotional state:</i> Geriatric Depression Scale	Score >5	12%	AUC=0.66 (0.50, 0.82)	AUC=0.64 (0.48, 0.80)	AUC=0.65 (0.48, 0.82)	VES/ECOG=0.76 VES/KPS=0.85 ECOG/KPS=0.77
<i>Social support:</i> medical outcomes social support sub-scale	Scoring in the lowest quartile	27%	AUC=0.57 (0.45, 0.71)	AUC=0.55 (0.43, 0.67)	AUC=0.57 (0.44, 0.69)	VES/ECOG=0.64 VES/KPS=0.86 ECOG/KPS=0.53