

Phase II Study of Abiraterone Acetate in Chemotherapy-Naive Metastatic Castration-Resistant Prostate Cancer Displaying Bone Flare Discordant with Serologic Response

Charles J. Ryan¹, Shreya Shah¹, Eleni Efstathiou², Matthew R. Smith³, Mary-Ellen Taplin⁴, Glenn J. Bubley⁵, Christopher J. Logothetis², Thian Kheoh⁶, Christine Kilian¹, Christopher M. Haqq⁶, Arturo Molina⁶, and Eric J. Small¹

Abstract

Purpose: Abiraterone is an oral inhibitor of CYP17, which is essential for androgen biosynthesis. This multicenter study assessed its efficacy in patients with castration-resistant prostate cancer (CRPC), without prior chemotherapy or CYP17-targeted therapy, and frequency of bone scans discordant with prostate-specific antigen (PSA) and clinical response.

Experimental Design: Thirty-three patients received abiraterone acetate 1,000 mg daily with prednisone 5 mg twice daily in continuous 28-day cycles. Patients were evaluated monthly for efficacy and safety. Bone scan flare was defined as the combination, after 3 months of therapy, of an interpreting radiologist's report indicating "disease progression" in context of a 50% or more decline in PSA level, with scan improvement or stability 3 months later.

Results: A 50% or more decline in PSA level at week 12 was confirmed in 22 of 33 (67%) patients. Declines in PSA level of 50% or more were seen in 26 of 33 (79%) patients. Undetectable PSA levels (≤ 0.1 ng/mL) occurred in 2 patients. Median time on therapy and time to PSA progression were 63 weeks and 16.3 months, respectively. Twenty-three patients were evaluable for bone scan flare. Progression was indicated in radiologist's report in 12 of 23 (52%), and 11 of 12 subsequently showed improvement or stability. As prospectively defined, bone scan flare was observed in 11 of 23 (48%) evaluable patients or 11 of 33 (33%) enrolled patients. Adverse events were typically grade 1/2 and consistent with prior published abiraterone reports.

Conclusion: Clinical responses to abiraterone plus prednisone were frequent and durable in men with metastatic CRPC. Further investigation is needed to clarify the confounding effect of bone scan flare on patient management and interpretation of results. *Clin Cancer Res*; 17(14); 4854–61. ©2011 AACR.

Introduction

As data emerge suggesting that the progression of prostate cancer in an androgen-deprived milieu is, in part, mediated through the selective growth of tumor cells with

a heightened sensitivity to androgens (1–4), progress and interest in the development of therapies that target extragonadal androgen synthesis have accelerated (5, 6). Abiraterone acetate is an orally available selective androgen biosynthesis inhibitor that specifically inhibits CYP17. Abiraterone has shown activity as a monotherapy in castration-resistant prostate cancer (CRPC) in both chemotherapy-naive and chemotherapy-exposed patients receiving a luteinizing hormone–releasing hormone (LHRH) analogue (7–12).

On the basis of the phase I experience with abiraterone acetate monotherapy, it was determined that the safety profile of this therapy could be improved through concomitant corticosteroid administration, an approach that reduces the compensatory elevations in adrenocorticotropic hormone (ACTH) and mineralocorticoid excess induced by CYP17 blockade. Because corticosteroids have shown modest antitumor efficacy when given as monotherapy, the current phase II study was designed to determine the efficacy and safety of the combination of abiraterone acetate and prednisone in patients with metastatic CRPC. In particular,

Authors' Affiliations: ¹Genitourinary Medical Oncology Program, UCSF Helen Diller Family Comprehensive Cancer Center, University of California-San Francisco, San Francisco, California; ²MD Anderson Cancer Center, Houston, Texas; ³Division of Hematology-Oncology, Massachusetts General Hospital; ⁴Dana-Farber Cancer Institute; ⁵Beth Israel Deaconess Medical Center, Boston, Massachusetts; and ⁶Ortho Biotech Oncology Research and Development, a Unit of Cougar Biotechnology, Los Angeles, California

Note: Presented in part at the 2009 American Society of Clinical Oncology Annual Meeting, Orlando, Florida, and the 2009 American Society of Clinical Oncology Genitourinary Cancers Symposium, Orlando, Florida.

Corresponding Author: Charles J. Ryan, Helen Diller Family Comprehensive Cancer Center, University of California, San Francisco, 1600 Divisadero Street, San Francisco, CA 94115. Phone 415-353-9279; Fax: 415-353-7779; E-mail: ryanc@medicine.ucsf.edu

doi: 10.1158/1078-0432.CCR-11-0815

©2011 American Association for Cancer Research.

Translational Relevance

Castration-resistant prostate cancer (CRPC) is a lethal disease and depends on androgen production and androgen receptor signaling for growth, affecting bone more than other distant sites. Abiraterone acetate, a selective androgen biosynthesis inhibitor of CYP17, has been shown to inhibit persistent androgen synthesis from adrenal and intratumoral sources, thereby suppressing an important stimulus of CRPC growth. This phase II study is the first assessment of abiraterone acetate in CRPC not previously treated with docetaxel or androgen synthesis inhibitors such as ketoconazole. Serial changes in objective imaging (i.e., bone scans) were utilized to assess patient outcomes. Discordant findings between serologic (prostate-specific antigen) response and increases in bone scan lesion intensity, although previously described in treatment-naïve prostate cancer, are reported here for the first time in CRPC. In addition to reporting prolonged antitumor activity of abiraterone acetate, this study highlights the potential detriment for patients if increased bone scan intensity is erroneously interpreted as disease progression.

the present trial is the first trial with abiraterone to focus on patients who had not been treated with either docetaxel or an androgen synthesis inhibitor, such as ketoconazole.

A well-recognized barrier to therapy development in CRPC is the lack of reliable surrogate markers of response to treatment coupled with a potentially exaggerated reliance on changes in serum prostate-specific antigen (PSA) as an indicator of treatment efficacy. This is particularly true with agents that have the potential for PSA modulation such as abiraterone acetate or ketoconazole. Consequently, changes in bone scan images have been advocated as important markers of disease response and progression. However, the utility of bone scans has been called into question because of a transient "flare" of bone lesion intensity in the context of treatment response resulting in a false determination of disease progression (13, 14). Although the bone scan flare has been described in breast cancer and in hormone-sensitive prostate cancer, no systemic evaluation of the flare phenomenon has been undertaken in CRPC (15, 16). Therefore, changes in objective imaging, particularly bone scans, were incorporated into this study in addition to PSA decline and time to PSA progression. As noted, these imaging changes are particularly important in the context of a novel agent that can potentially modulate PSA, potentially rendering it a less useful biomarker.

Patients and Methods

Patients

Eligibility required histologically confirmed adenocarcinoma of the prostate progressing on androgen deprivation

therapy (either an LHRH agonist or orchiectomy, and following antiandrogen withdrawal, as appropriate). PSA progression was defined according to Prostate-Specific Antigen Working Group (PSAWG) criteria (17), and all patients had to have baseline lesions identified by bone scan, computed tomography (CT), or MRI. Prior ketoconazole therapy or chemotherapy was not permitted, with the exception of neoadjuvant or adjuvant chemotherapy completed at least 1 year before study entry. Additional eligibility criteria included an Eastern Cooperative Oncology Group (ECOG) performance status of 0 or 1, adequate renal [serum creatinine $\leq 1.5 \times$ upper limit of normal (ULN)], hepatic [bilirubin $\leq 1.5 \times$ ULN, aspartate aminotransferase and alanine aminotransferase $\leq 2.5 \times$ ULN], and bone marrow (hemoglobin >9 gm/dL, absolute neutrophil count $>1.5 \times 10^9/L$, platelets $>100 \times 10^9/L$) function, serum potassium level 3.5 mmol/L or more, and a castrate level of testosterone (<50 ng/dL). Patients with clinically significant electrocardiogram (ECG) abnormalities were ineligible, as were patients with uncontrolled hypertension, New York Heart Association Class III or IV congestive heart failure, those with active autoimmune disease requiring corticosteroid therapy, or any other serious medical or psychiatric illness. Radiation therapy or initiation of bisphosphonate therapy within 4 weeks of study entry was not permitted, although maintenance of a stable bisphosphonate dose was allowed. Use of hormonal therapies, systemic corticosteroids, or any other agent known to decrease PSA levels within 4 weeks prior to study initiation was not permitted. Written informed consent was obtained from all patients.

Treatment and evaluations

Treatment consisted of abiraterone acetate 1,000 mg daily with prednisone 5 mg twice daily. Abiraterone was administered without food in 28-day cycles. Treatment was given continuously until there was evidence of disease progression in patients not experiencing unacceptable toxicity.

Screening evaluations included a history and physical examination, performance status evaluation, and a 12-lead ECG. Laboratory assessments included complete blood cell count, serum chemistries and electrolytes, blood clotting evaluation (prothrombin time, partial thromboplastin time, international normalized ratio), and serum PSA and testosterone levels. Baseline tumor imaging was done by bone scan, CT, MRI, or other imaging procedure. Selected physical and laboratory assessments were repeated on days 1 and 8 of cycle 1, on day 1 of each subsequent cycle, and at the end of study. PSA values were obtained monthly. Adverse events were graded using the National Cancer Institute Common Terminology Criteria for Adverse Events (CTCAE), version 3. Bone scans and tumor imaging studies were repeated every 3 cycles.

Study design and statistical considerations

This was a single-arm, open-label, multicenter phase II study conducted under the auspices of the Department of

Defense Prostate Cancer Clinical Trials consortium and sponsored by Cougar Biotechnology. The primary study endpoint was the proportion of patients achieving a 50% or more decline in PSA levels by week 12 of therapy. Secondary endpoints included durability of response as determined by time to PSA progression, objective radiographic response rate according to RECIST guidelines (18), radiographic progression-free survival time, overall survival time, clinical benefit as determined by disease stabilization, change in ECOG performance status, and overall treatment safety.

Bone scan flare was prospectively defined as discordant results after 3 months of therapy based on the combination of an interpreting radiologist's report indicating "disease progression," typically based on increased lesion intensity or number that occurred in the context of a 50% or more decline in PSA levels, which on subsequent reevaluation 3 months later showed improvement or stability in the scan. Thus, patients evaluable for bone scan flare included all patients who had bone scans available at baseline, after 3 months of therapy, and after 6 months of therapy. An initial flare at 3 months followed by continued declines in PSA levels and *stable* scans was also considered to be of interest and is reported separately from true flare.

A sample size of 32 evaluable patients was determined as necessary to detect a response rate of 50% or more, with response defined as 50% or more decline in PSA levels at 12 weeks from baseline measurement, at a significance level of 0.04 for a directional test and 81% power. Distributions of time-to-event variables were estimated using the Kaplan-Meier product limit method. All patients who received a minimum of 3 cycles of therapy were considered evaluable for response. All patients who received at least 1 dose of abiraterone acetate were evaluable for safety.

Adverse events were summarized by worst grade of severity per patient. The study protocol was approved by the institutional review boards at all participating sites and was conducted in accordance with the ethical principles of the World Medical Association Declaration of Helsinki.

Results

Patient characteristics and treatment

Between October 2007 and May 2008, a total of 33 men with metastatic prostate cancer progressing despite a castrate level of testosterone were enrolled across 5 study centers within the United States. Baseline patient demographics and clinical characteristics are shown in Table 1. The median baseline PSA level was 23 ng/mL and ranged from 5.9 to 1,110 ng/mL. All patients had radiographic evidence of metastatic disease and 26 of 33 (79%) had bony metastases. All patients had received androgen deprivation therapy with an LHRH antagonist ($N = 31$) or orchiectomy ($N = 2$), and 32 (97%) had also received an antiandrogen and undergone antiandrogen withdrawal. All patients had castrate serum testosterone levels (median 8.5 ng/dL; range, 0.9–24.1 ng/dL). The

Table 1. Baseline demographic and clinical characteristics of 33 patients enrolled in a phase II trial of abiraterone acetate plus prednisone

	Baseline value
PSA, median (range), ng/mL	23.0 (5.9–1,110.0)
Metastases, n (%)	
Visceral only	1 (3)
Viscera plus bone/soft tissue	2 (6)
Bone only	10 (30.3)
Soft tissue only	6 (18.2)
Bone and soft tissue only	14 (42.4)
Gleason score, median (range)	8 (5–9)
Hemoglobin, median (range), g/dL	12.8 (10.6–15.3)
Testosterone, median (range), ng/dL	25.5 (4.0–49.0)
Alkaline phosphatase, median (range), units/L	82.0 (39.0–1,078.0)
Number of hormonal therapies, median (range)	2 (2–4)

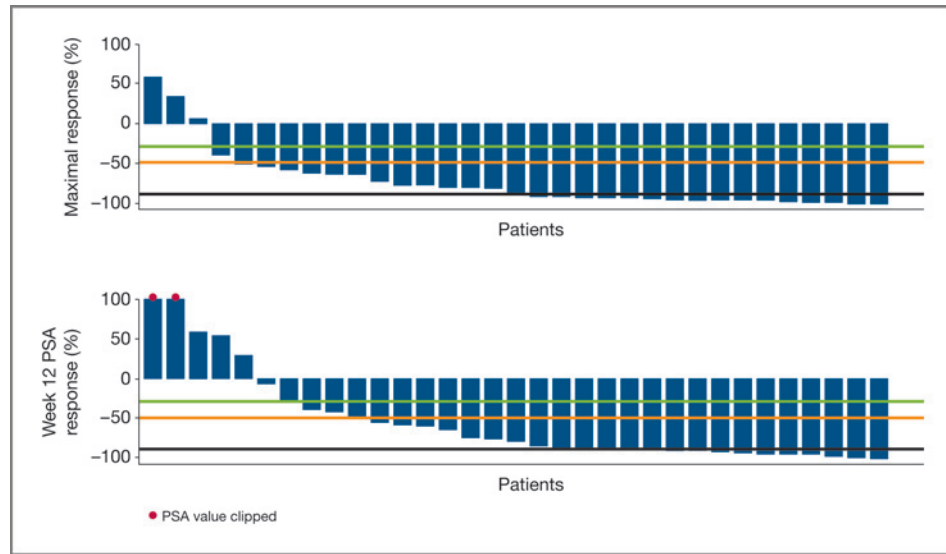
majority of patients (88%) had received 2 prior hormonal therapies, with 3 patients (9%) having received up to 4 hormonal therapies including estrogens or glucocorticoids. No patient had undergone prior treatment with abiraterone, ketoconazole, or chemotherapy. At the time of analysis (January 2010), the study population had received a median of 63 weeks (range, 8–104 weeks) of treatment with abiraterone acetate plus prednisone, with 15 patients (46%) continuing to receive therapy. Treatment had been discontinued secondary to disease progression in 14 patients (42%) and adverse events in 3 patients (9%); 2 patients discontinued treatment as a result of grade 3 adverse events (1 each for back pain and pathologic fracture). Twenty-three patients were evaluable for the bone flare phenomenon. All 33 patients were evaluable for response and safety.

PSA response and durability

Changes in PSA levels, both after 3 months of therapy and maximal, for each patient are depicted in Figure 1. A decline in PSA level of 50% or more after 3 months, the primary study endpoint, was confirmed in 22 (67%) of 33 patients. Confirmed maximal declines in PSA levels of 50% or more and 90% or more were seen in 26 (79%) and 15 (46%) patients, respectively. In 2 patients, PSA levels became undetectable (≤ 0.1 ng/mL), declining from baseline values of 204 ng/mL and 9 ng/mL, respectively. These patients continued to receive study therapy after 20 and 21 months, both with continued stable bone scans and resolution of adenopathy in 1 patient.

Median follow-up time for this analysis was 19.3 months. The median time to PSA progression was 16.3

Figure 1. Changes in PSA levels in CRPC patients treated with abiraterone acetate plus prednisone. Waterfall plots of maximal PSA change (top) and PSA change at week 12 (bottom). Reference lines: black, -90%; orange, -50%; green, -30%.



months [95% CI 9.2 months, not estimable; Fig. 2]. Nineteen (58%) patients received study treatment for at least 12 months.

Objective tumor response

Of 13 patients with measurable disease consisting of lymphadenopathy, 9 (69%) had a partial response and 3 (23%) had stable disease.

Bone scan results and bone scan flare

At baseline, 26 patients had positive bone scans. One had a solitary bone metastasis, 7 patients had between 2 and 4 metastases, and 18 patients had more than 4 discrete metastases. Twenty-three patients had the combination of a positive baseline bone scan, a 50% or more decline in PSA after 3 months, and bone scans at 3 and 6 months and thus were available for evaluation of bone scan flare. Reports were available on 92 total bone scans from 41 unique

radiologists dispersed geographically among the study sites. Of the 23 eligible patients, bone scan progression was indicated in the radiologists' reports in 12 (52%) of the scans taken after 3 months of therapy. Four of the 12 patients had a report worded specifically as "progression of disease" without new lesions (e.g., based solely on increased intensity of existing lesions), whereas for 8 of 12 patients, progression of disease due to new lesions was noted. For imaging following 6 months of therapy, the radiologists' reports indicated subsequent improvement in 4 of 12 and stability in 7 of 12 patients. One patient had a worsened scan at 6 months despite continued PSA decline, showing a new lesion. Thus, overall, bone scan flare, as defined by the combination of PSA decline, initial flare, and subsequent improvement or stability in bone scans at 6 months, was observed in 4 of 23 (17%) and 7 of 23 (30%) evaluable patients and 4 of 33 (12%) and 7 of 33 (21%) enrolled patients, respectively.

Two responding patients were not evaluable for bone scan flare: 1 had persistent declines in PSA levels (from baseline to the end of month 3 and from month 3 through month 6 of therapy), with a negative bone scan at baseline that was not repeated; the second discontinued study therapy after 4 months on therapy because of a pathologic femoral neck fracture despite a decline in PSA level of 91.7%.

In the 11 patients with bone flare at 3 months and stable or improved scans at 6 months, median age was 72 years (range, 54–85), median PSA level at baseline was 21.9 ng/dL (range, 6.8–204.3), and median alkaline phosphatase level at baseline was 88.5 units/L (range, 49.0–372.0), not significantly different from the study population as a whole. Alkaline phosphatase levels did not change in patients experiencing flare: median baseline value was 88.5 units/L. After 3 months of therapy, the median remained at 88.5 units/L and after 6 months, it was 83.5 units/L. Four patients had less than 4 metastases,

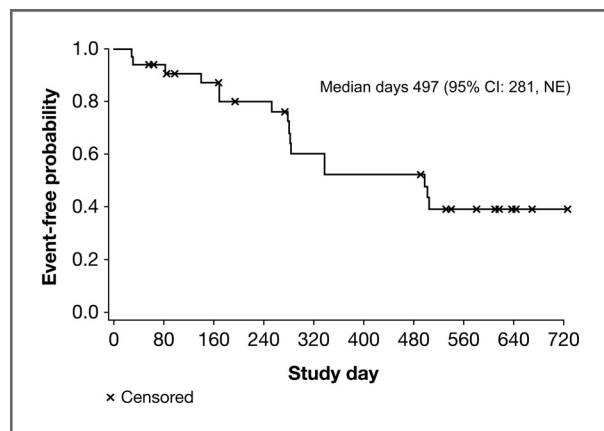


Figure 2. Time to PSA progression in CRPC patients treated with abiraterone acetate and prednisone (N = 33). NE, not estimable.

Downloaded from <http://aacrjournals.org/clinccancerres/article-pdf/17/14/4854/1997032/4854.pdf> by guest on 12 February 2025

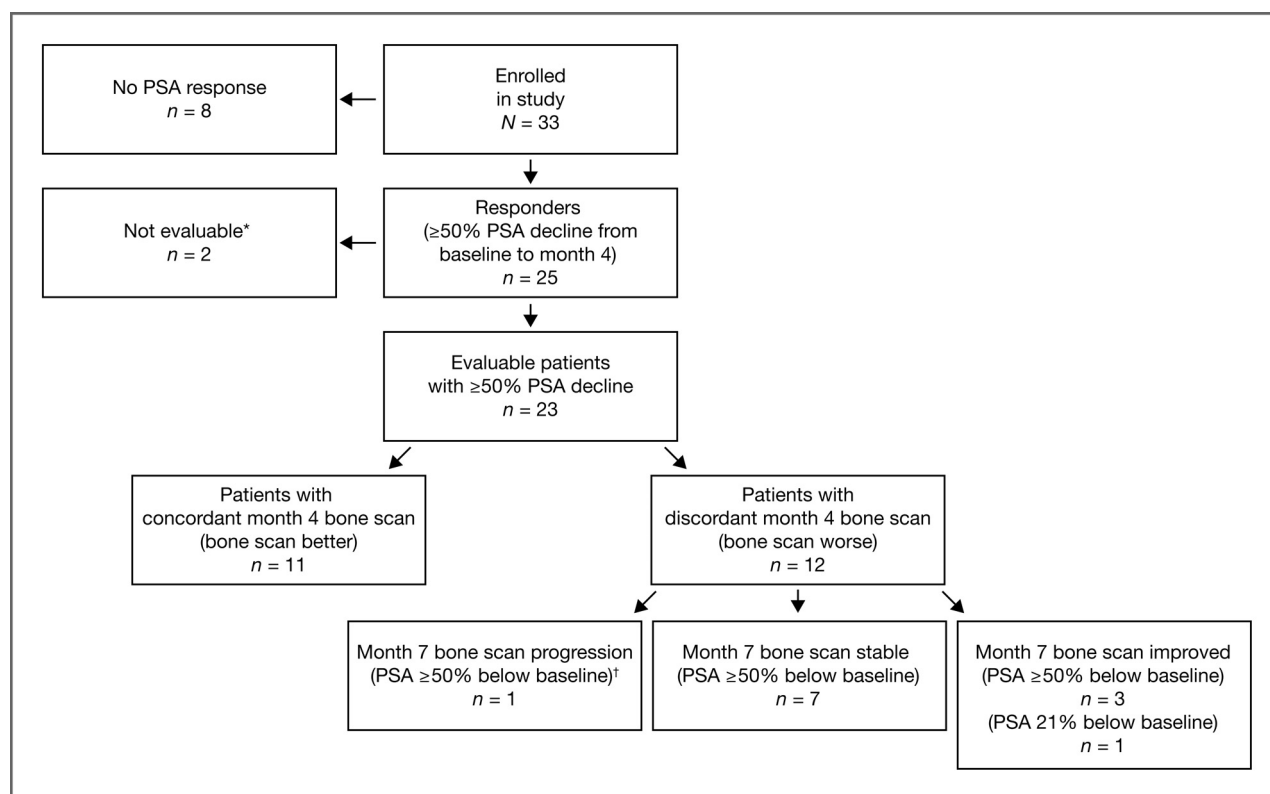


Figure 3. Disposition of patients who did and did not experience a bone scan flare. *, of the 2 patients, 1 patient had a negative bone scan at baseline that was not repeated given the decline in PSA level; 1 patient came off study at month 4 due to a pathologic femoral neck fracture. †, patient came off study after month 9 (and thus never underwent another bone scan).

and 7 patients had multifocal disease. Patient disposition is summarized in Figure 3.

Radiologist interpretation of bone scans in these 11 patients was as follows: 4 patients had month 4 bone scans being read as having increased intensity of existing lesions; the other 7 patients had bone scans that were read as having new lesions (Fig. 4). Of these 11 patients with flare, 10 maintained a decline in PSA levels of 50% or more from baseline and 1 developed an increase in PSA level from month 4 to month 7 of 4.9 ng/dL (73% increase above nadir and 21% decline from baseline) after 6 months. The remaining patient with discordant results following 3 months of therapy continued to have decline in PSA levels past 3 months but had a bone scan after 6 months of therapy that was interpreted as progressive disease. This patient came off study after 8 months of therapy (and thus never underwent another bone scan).

Safety

Adverse events were most often grade 1 or 2 (see Table 2) and clinically manageable. The most common treatment-related adverse events were fatigue, hot flush, bone pain, peripheral edema, arthralgia, dizziness, and hypokalemia. In addition to those listed in Table 2, there was a single occurrence each of grade 3 supraventricular arrhythmia and

atrial flutter. One incident each of grade 3 hypokalemia and hypertension was observed.

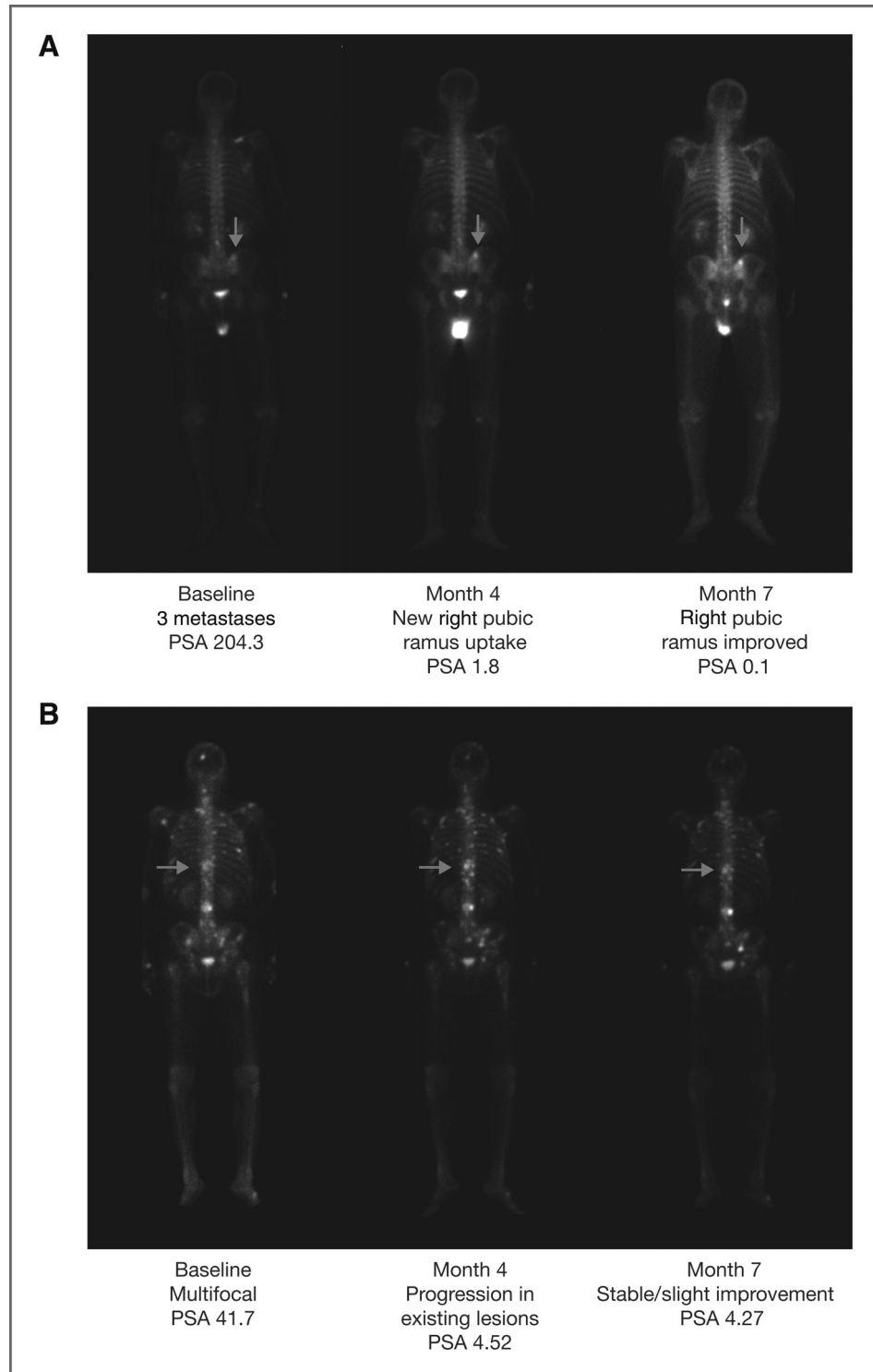
Discussion

In the current study, a large proportion of patients (67%) with CRPC experienced a 50% or more decline in serum PSA levels while on abiraterone acetate, an effect that persisted for more than 1 year in more than half of patients. An important and surprising observation in this study was that discordant bone scan findings after 3 months of therapy were observed in a large proportion of patients (36% of the total and 48% of those who experienced a $\geq 50\%$ decline in PSA levels).

In this study, the potential clinical utility of abiraterone acetate in CRPC used determinants of efficacy that included decline in PSA levels, time to PSA progression, and changes in objective imaging with bone scan and CT scans. Evaluation of bone scans resulted in an observation of a high incidence of bone flare during the first 6 months of the study.

Potential confounding variables that may lead to erroneous determination that a flare has occurred were considered. These included the possibility of a significant delay between baseline bone scan and initiation of therapy (and therefore disease progression before starting therapy) and

Figure 4. Examples of bone scan flare in patients receiving abiraterone acetate. **A**, example of a patient with a declining PSA level but a month 4 bone scan being read as having a new metastasis in the right pubic ramus, as indicated by the arrow (although in retrospect, one can see the lesion in the baseline bone scan). By month 7, this lesion shows improvement, indicating that this lesion seen at month 4 was present at baseline and thus was secondary to bone flare. **B**, example of a patient with a declining PSA level but a month 4 bone scan being read as progression in existing lesions. By month 7, this progression improved, indicating that the progression seen at month 4 was due to bone flare.



bisphosphonate initiation. All patients initiated treatment within 28 days of the baseline bone scan, and initiation of bisphosphonate therapy was not permitted within 28 days before starting or at any time while on the study, thus decreasing the possibility that these factors falsely elevated the incidence of diagnosed flare.

The high incidence of the discordant interpretation of bone scans by radiologists in the presence of a 50% or more decline in PSA levels highlights several important issues related to study design and management of CRPC. First, this phenomenon is not systematically assessed in the setting of highly active, hormonal therapies that

Table 2. Incidence of most frequent ($\geq 10\%$) treatment-related adverse events^a ($N = 33$)

Toxicity by preferred term	<i>n</i> (%) of patients				
	Total grade 1–4	Grade 1	Grade 2	Grade 3	Grade 4
Fatigue	15 (46)	8 (24)	6 (18)	1 (3)	0
Hot flush	10 (30)	7 (21)	3 (9)	0	0
Bone pain	8 (24)	6 (18)	1 (3)	1 (3)	0
Peripheral edema	8 (24)	7 (21)	0	1 (3)	0
Arthralgia	7 (21)	6 (18)	1 (3)	0	0
Dizziness	7 (21)	6 (18)	0	1 (3)	0
Hypokalemia	7 (21)	6 (18)	0	1 (3)	0
Back pain	6 (18)	3 (9)	2 (6)	1 (3)	0
Hypertension	6 (18)	3 (9)	2 (6)	1 (3)	0
Muscle spasms	6 (18)	6 (18)	0	0	0
Constipation	5 (15)	5 (15)	0	0	0
Ecchymosis	5 (15)	4 (12)	1 (3)	0	0
Hyperbilirubinemia	5 (15)	4 (12)	1 (3)	0	0
Hyperglycemia	5 (15)	2 (6)	2 (6)	1 (3)	0
Contusion	4 (12)	4 (12)	0	0	0
Nausea	4 (12)	3 (9)	1 (3)	0	0
Musculoskeletal pain	4 (12)	2 (6)	2 (6)	0	0
Pain in extremity	4 (12)	3 (6)	1 (3)	0	0
Upper respiratory tract infection	4 (12)	2 (6)	2 (6)	0	0
Vomiting	4 (12)	3 (9)	1 (3)	0	0

^aMost frequent according to the total percentage observed.

modulate PSA expression in CRPC. As a result, incorporation of these data into subsequent phase II and phase III designs may further clarify the clinical meaning of this phenomenon (e.g., whether it predicts a favorable long-term outcome). Second, it suggests that there may be an initial discordance between PSA and bone scan that will change with time, in many cases leading to the stable presence of bone lesions following an initial increase in tracer uptake. Of note, consensus criteria such as the Prostate Cancer Working Group 2 (PCWG2) formally addresses bone flare and includes the recommendation to carry out a first follow-up bone scan 12 or more weeks after the start of therapy; and furthermore defines progression in bone when a minimum of 2 new lesions are observed and confirmed on a second scan done 6 or more weeks later (19). These bone flare findings further highlight a need for closer communication between clinicians and interpreting radiologists. This phase II study did not mandate central review of scans, nor did it require that scans be carried out at the main clinical site of the study. Indeed, there were 41 individual radiologists from 4 different states (Massachusetts, Texas, New Mexico, and California) who interpreted 92 bone scans in this study, which suggests that these results are not the result of an institutional or regional bias. Therefore, it is necessary that this phenomenon be recognized to avoid prematurely discontinuing efficacious therapy on the basis of a potentially erroneous bone scan interpretation. Mandat-

ing central review of scans where possible is recommended. Finally, bone flare can potentially be evaluated by the measurement of markers of bone turnover, as changes in bone-specific isoenzyme of alkaline phosphatase and osteocalcin have been reported to be sensitive predictors of subsequent radiologic response (20). These parameters may provide useful clinical information to a physician after only 1 month of therapy, long before radiologic evidence of response can be expected (21). Imaging techniques, such as positron emission tomography, utilizing novel tracers such as radiolabeled dihydrotestosterone, are also in development as a potential means to more specifically image androgen receptor and ligand interactions.

The PSA response proportion of 67% in this study is slightly higher than that observed in previous phase II studies with abiraterone acetate (36%–55%; refs. 9, 12, 22). Potential explanations for this observation are many and include the fact that this was a population with less extensive disease than in past studies (e.g., median PSA level was 23 in this study), no patients were previously treated with either chemotherapy or CYP17 inhibitors such as ketoconazole, and finally that prednisone may contribute to a modest increase in the likelihood of a decline in PSA levels.

Grade 3 and 4 toxicities were infrequent in this study, and toxicities related to mineralocorticoid excess that were observed in earlier studies of abiraterone acetate

without steroid replacement therapy were rare (9–12). Although hypokalemia remained a common event, it occurred with lower incidence and severity than was observed in patients previously treated with steroid replacement therapy. This decrease was most likely due to suppression of the compensatory increase in ACTH levels by prednisone, as well as a heightened awareness of this potential toxicity and early intervention with potassium supplementation.

Collectively, these results, as well as the favorable long-term safety profile of this combination, suggest that this therapy is highly active in CRPC. Advancement of this dose and schedule of abiraterone to a pivotal phase III study in this patient population is warranted.

References

- Chen CD, Welsbie DS, Tran C, Baek SH, Chen R, Vessella R, et al. Molecular determinants of resistance to antiandrogen therapy. *Nat Med* 2004;10:33–9.
- Holzbeierlein J, Lal P, LaTulippe E, Smith A, Satagoapn J, Zhang L, et al. Gene expression analysis of human prostate carcinoma during hormonal therapy identifies androgen-responsive genes and mechanisms of therapy resistance. *Am J Pathol* 2004;164:217–27.
- Mostaghel EA, Page ST, Lin DW, Fazli L, Coleman IM, True LD, et al. Intraprostatic androgens and androgen-regulated gene expression persist after testosterone suppression: therapeutic implications for castration-resistant prostate cancer. *Cancer Res* 2007;67:5033–41.
- Montgomery RB, Mostaghel EA, Vessella R, Hess DL, Kalthorn TF, Higano CS, et al. Maintenance of intratumoral androgens in metastatic prostate cancer: a mechanism for castration-resistant tumor growth. *Cancer Res* 2008;68:4447–54.
- Small EJ, Halabi S, Dawson NA, Stadler WM, Rini BI, Picus J, et al. Antiandrogen withdrawal alone or in combination with ketoconazole in androgen-independent prostate cancer patients: a phase III trial (CALGB 9583). *J Clin Oncol* 2004;22:1025–33.
- Ryan CJ, Halabi S, Ou SS, Vogelzang NJ, Kantoff P, Small EJ. Adrenal androgen levels as predictors of outcome in prostate cancer patients treated with ketoconazole plus antiandrogen withdrawal: results from a cancer and leukemia group B study. *Clin Cancer Res* 2007;13:2030–7.
- Barrie SE, Potter GA, Goddard PM, Haynes BP, Dowsett M, Jarman M. Pharmacology of novel steroidal inhibitors of cytochrome P450(17) alpha (17 alpha-hydroxylase/C17–20 lyase). *J Steroid Biochem Mol Biol* 1994;50:267–73.
- O'Donnell A, Judson I, Dowsett M, Raynaud F, Dearnaley D, Mason M, et al. Hormonal impact of the 17alpha-hydroxylase/C(17,20)-lyase inhibitor abiraterone acetate (CB7630) in patients with prostate cancer. *Br J Cancer* 2004;90:2317–25.
- Ryan CJ, Smith MR, Fong L, Rosenberg JE, Kantoff P, Raynaud F, et al. Phase I clinical trial of the CYP17 inhibitor abiraterone acetate demonstrating clinical activity in patients with castration-resistant prostate cancer who received prior ketoconazole therapy. *J Clin Oncol* 2010;28:1481–8.
- Attard G, Reid AH, A'Hern R, Parker C, Oommen NB, Folkard E, et al. Selective inhibition of CYP17 with abiraterone acetate is highly active in the treatment of castration-resistant prostate cancer. *J Clin Oncol* 2009;27:3742–8.
- Attard G, Reid AH, Yap TA, Raynaud F, Dowsett M, Sattatree S, et al. Phase I clinical trial of a selective inhibitor of CYP17, abiraterone

Disclosure of Potential Conflicts of Interest

C.M. Haqq, A. Molina, and T. Kheoh are employed by Cougar Biotechnology. E.J. Small is a compensated advisor to Cougar Biotechnology. C.J. Logothetis, M.R. Smith, and E. Efstathiou are uncompensated advisors to Cougar Biotechnology. The other authors disclosed no potential conflicts of interest.

Grant Support

This study was supported by Cougar Biotechnology and the Department of Defense Prostate Cancer Clinical Trials Consortium.

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked *advertisement* in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

Received March 28, 2011; revised May 26, 2011; accepted May 27, 2011; published OnlineFirst June 1, 2011.

- acetate, confirms that castration-resistant prostate cancer commonly remains hormone driven. *J Clin Oncol* 2008;26:4563–71.
- Reid AH, Attard G, Danila DC, Oommen NB, Olmos D, Fong PC, et al. Significant and sustained antitumor activity in post-docetaxel, castration-resistant prostate cancer with the CYP17 inhibitor abiraterone acetate. *J Clin Oncol* 2010;28:1489–95.
 - Johns WD, Garnick MB, Kaplan WD. Leuprolide therapy for prostate cancer. An association with scintigraphic "flare" on bone scan. *Clin Nucl Med* 1990;15:485–7.
 - Sundkvist GM, Ahlgren L, Lilja B, Mattsson S, Abrahamsson PA. Dynamic quantitative bone scintigraphy in patients with prostatic carcinoma treated by orchiectomy. *Eur J Nucl Med* 1990;16:671–6.
 - Janicek MJ, Hayes DF, Kaplan WD. Healing flare in skeletal metastases from breast cancer. *Radiology* 1994;192:201–4.
 - Pollen JJ, Shlaer WJ. Osteoblastic response to successful treatment of metastatic cancer of the prostate. *Am J Roentgenol* 1979;132:927–31.
 - Bubley GJ, Carducci M, Dahut W, Dawson N, Daliani D, Eisenberger M, et al. Eligibility and response guidelines for phase II clinical trials in androgen-independent prostate cancer: recommendations from the Prostate-Specific Antigen Working Group. *J Clin Oncol* 1999;17:3461–7.
 - Therasse P, Arbuck SG, Eisenhauer EA, Wanders J, Kaplan RS, Rubinstein L, et al. New guidelines to evaluate the response to treatment in solid tumors. European Organization for Research and Treatment of Cancer, National Cancer Institute of the United States, National Cancer Institute of Canada. *J Natl Cancer Inst* 2000;92:205–16.
 - Scher HI, Eisenberger M, D'Amico AV, Halabi S, Small EJ, Morris M, et al. Eligibility and outcomes reporting guidelines for clinical trials for patients in the state of a rising prostate-specific antigen: recommendations from the Prostate-Specific Antigen Working Group. *J Clin Oncol* 2004;22:537–56.
 - Coleman RE, Mashiter G, Fogelman I, Whitaker KD, Caleffi M, Moss DW, et al. Osteocalcin: a potential marker of metastatic bone disease and response to treatment. *Eur J Cancer Clin Oncol* 1988;24:1211–7.
 - Sundkvist GM, Ahlgren L, Lilja B, Mattsson S. Quantitative bone scintigraphy in prostatic carcinoma—long-term response to treatment. *Nuklearmedizin* 1993;32:231–5.
 - Danila DC, Morris MJ, de Bono JS, Ryan CJ, Denmeade SR, Smith MR, et al. Phase II multicenter study of abiraterone acetate plus prednisone therapy in patients with docetaxel-treated castration-resistant prostate cancer. *J Clin Oncol* 2010;28:1496–501.