CABERGOLINE MONOTHERAPY IN THE LONG-TERM TREATMENT
OF CUSHING’S DISEASE

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ABSTRACT

Background: Cabergoline is a long-acting dopamine receptor agonist used to treat prolactinomas. Identification of D2-receptors in corticotroph tumors led to clinical trials of cabergoline therapy in limited cases of Nelson’s syndrome, ectopic ACTH-secreting tumors and recently Cushing’s disease (CD).

Objective: Evaluate the long-term efficacy of cabergoline monotherapy in patients with CD.

Methods: Retrospective analysis of non-randomized clinical therapy with cabergoline in 30 patients with CD treated in academic centers of Buenos Aires and Montreal. Cabergoline was initiated at 0.5-1.0 mg/wk and adjusted up to a maximal dose of 6 mg/wk based on urinary free cortisol (UFC) levels. Complete response to cabergoline was defined as a sustained normalization of UFC with at least two normal values measured at 1 to 3 months interval; partial response was defined as a decrease of UFC to <125% of the upper limit of normal, and treatment failure as UFC ≥125% of it.

Results: Within 3-6 months, complete response was achieved in 11 patients (36.6%) and partial response in 4 (13.3%). After longer term therapy, 9 patients (30%) remain with a complete response after a mean of 37 months (range from 12-60 months) with a mean dose of 2.1 mg/wk of cabergoline. Two patients escaped after 2 and 5 years of complete response, but one transiently renormalized UFC after an increase in cabergoline dosage. No long-term response was maintained in 4 initial partial responders.

Conclusions: Cabergoline monotherapy can provide an effective long-term medical therapy for selected patients with CD, but requires close follow-up for dose adjustments.
INTRODUCTION

Cushing’s disease (CD) is caused by ACTH-secreting pituitary adenomas in the majority of cases and is the most frequent etiology of endogenous Cushing’s syndrome (CS). The resulting hypercortisolism in CD is responsible for important cardiovascular, metabolic and other morbidities (1).

Transsphenoidal surgery is the initial treatment of choice for most patients with CD. The therapeutic objectives of surgery include complete and selective resection of the ACTH-secreting pituitary adenoma, correction of the hypercortisolemic state and its complications, and maintenance of other pituitary functions (2). After a first surgery, remission rates reach 70-80% in series from major centres as defined by suppressed plasma cortisol levels and normal 24-hour urinary free cortisol (UFC), with concomitant resolution of clinical stigmata (2). Surgery success rates can reach 90% in selective adenomectomy of microadenomas but decrease to 65% in macroadenomas (1-3).

The long term follow-up of patients with CD initially in remission following a first pituitary surgery reveals at 10 years a recurrence rate of 10-20% for subjects presenting with a microadenoma (2-4) and up to 45% for macroadenomas (1-3). Compared to the patients with microadenomas, clinical CD relapses with a shorter delay in subjects with larger tumors (3).

Management of persistent or recurrent CD is a challenge. In ultra specialized centers, a second pituitary surgery has a lower than 50% success rate in limited series and carries a high risk of hypopituitarism, often with undesirable effects on fertility (2,5-7). Pituitary irradiation, either by conventional or stereotactic radiotherapy, achieves eucortisolism in 50 to 60% of cases but with 3 to 5 years of delay (2). In addition, radiotherapy is associated with a high rate of pituitary insufficiency and possible risks of cognitive impairment, brain vascular morbidity or
secondary neoplasms (2). Bilateral adrenalectomy can also be utilized as a final approach and will control rapidly the clinical manifestations of CD, but it presents a non negligible risk of Nelson’s syndrome (8-29%) and requires life-long glucocorticoid/mineralocorticoid replacement (2,8).

Some pharmacological therapies, mainly adrenal blocking agents, have also been used to control hypercortisolism, often as a bridge before surgery or while awaiting for the effects of radiotherapy (2,9-10). However, steroidogenesis inhibitors or the adrenolytic agent mitotane have limited efficacy or cause side effects that restrain their long-term utilisation.

A molecule specifically able to control ACTH production and corticotroph tumor growth would constitute a major improvement in the management of CD. Some pituitary-directed medical therapies have been proposed but provided inconsistent results (2). Studies using dopamine agonists like bromocriptine or cabergoline were initiated based on the demonstration of D₂ receptor expression in corticotroph tumors (11) and their ability to reduce ACTH and cortisol secretion in in vitro and in vivo studies (11-13). The effectiveness of bromocriptine was first reported in Nelson’s syndrome and in the short-term treatment of CD with a shrinkage effect on pituitary tumors (14-17). However, long-term studies with bromocriptine demonstrated limited efficacy, with less than 30% of response during chronic treatment (9-10,18). For cabergoline, initial case reports and small series reported a similar ability to control ACTH and cortisol secretion in patients with Nelson’s syndrome (19-20) and ectopic ACTH secreting tumors (21). A higher affinity and specificity of cabergoline for D₂ receptors in addition to its longer half life (22-23) could explain its better efficacy in CD, which have ranged from 25% to 75% in short course treatment of persistent or recurrent CD (24-29). Pivonello et al. (30) reported long-term effectiveness of cabergoline to control CD in 8 of 20 patients (40%) without
significant side effects during 24 months of therapy. More recently, Vilar et al. (29) found a 25% complete response to cabergoline monotherapy in 12 CD patients receiving a maximal dose of 3 mg/wk of cabergoline during 6 months; combination therapy with low-dose of ketoconazole (200-400 mg/d) induced normalization of UFC in two-thirds of patients with persisting elevations of UFC.

The aim of the present study was to evaluate the long-term effects of cabergoline monotherapy in a cohort of 30 patients with CD including three patients as first line therapy and 27 patients treated for persistent/ recurrent CD.

PATIENTS AND METHODS

Thirty patients with CD were treated with cabergoline (25 females, 5 males; between 20 to 67 yr of age) between 2002 and 2006 in the cohorts of the endocrinology divisions of the Hospital de Clinicas of the University of Buenos Aires (18 patients) and at the Centre hospitalier de l’Université de Montréal (12 patients). Retrospective analysis of those cases was performed. The initial diagnosis of CD was based upon: 1) elevated 24-hour UFC levels with inappropriately normal/high plasma ACTH concentrations, 2) abnormal suppression of cortisol following low-dose and/or high-dose dexamethasone suppression tests and 3) evidence of a pituitary source of ACTH during petrosal sinus sampling or a pituitary tumor on magnetic resonance imaging (MRI). Persistence or recurrence of CD after transsphenoidal surgery was defined as 1) histological and immunohistological confirmation of corticotroph adenoma on the surgical specimen and 2) sustained elevation of UFC levels and abnormal suppression of cortisol following dexamethasone suppression test with clinical manifestations of hypercortisolism. At diagnosis or at time of relapse, before introduction of cabergoline, 24-hour UFC varied from 105
to 692% of the upper limit of normal range with a mean at 283%. Six patients had documented concomitant hyperprolactinemia before treatment at respectively 26, 27, 37, 45, 78 and 360 ng/mL (normal values below 25 ng/mL). At the time of initial diagnosis, a pituitary tumor was clearly identified in 23 cases (19 microadenomas, 4 macroadenomas), a radiological small microadenoma was suspected in two subjects, and none was detectable in 5 patients.

When cabergoline was introduced, no clear residual pituitary adenoma was identified in the majority of subjects with recurrent CD; 2 had unrelated anomalies on the MRI: a hypothalamic vascular lesion and a post-surgical empty sella. Clinical and hormonal profile of these two subjects was similar to the others patients before introduction of cabergoline treatment. The initial clinical and biochemical profiles of all patients are shown in Table 1. Cabergoline was used as first line therapy in three patients, and was introduced in the context of persistent or recurrent CD after initial pituitary surgery in 27 subjects. Cabergoline was introduced 9 months after initial pituitary surgery in two cases with residual disease. In other patients, cabergoline therapy was started between 2 and 17 years after relapse which occurred after initial remission from first transsphenoidal surgery. For patient no 22, cabergoline was introduced 4 years after initial pituitary surgery and 3 years after conventional pituitary radiotherapy.

**STUDY DESIGN**

Based on the initial reports on the efficacy of cabergoline in subjects with CD or Nelson’s syndrome (11,19-20), patients with residual/persistent CD were offered cabergoline therapy after discussing the possible alternative modalities: a second pituitary surgery, radiotherapy, other medications (steroidogenesis inhibitors, adrenolytic agents) or bilateral adrenalectomy. Patients were informed of the off-label use of this drug for CD and gave oral consent to its administration.
to evaluate if it could control their hypercortisolism. Cabergoline (Dostinex; Paladin
Laboratories, Montreal, Quebec, Canada and Pfizer, Buenos Aires, Argentina) was initiated at a
dose of 0.5 to 1.0 mg/wk and was increased progressively by 0.5 or 1.0 mg/wk at one or two
months interval until complete and sustained normalization of UFC levels. As there was no
formal protocol, the treating physicians decided on an individual basis to stop or increase the
dose of cabergoline up to a maximal dose of 6 mg/wk. All patients with CD who received
 cabergoline in the two centers were included in the retrospective analysis. Review of the charts
of the 30 subjects focused on the long-term effects of cabergoline treatment, biochemical and
clinical features of CD as well as the possible side effects reported by the patients. Plasma
ACTH and prolactin concentrations were measured at each centre by immunometric assay
whereas serum and UFC levels were determined using enzyme immunoassay or RIA after
extraction with dichloromethane.

CRITERIA OF RESPONSE TO TREATMENT

During evaluation and follow-up of patients, UFC was measured successively during one
to three 24-hour periods at intervals of 1 to 2 months based on clinical indications. Complete
response to cabergoline was defined as normalization of the mean UFC levels at time of
assessment. A decrease in UFC to less than 125% of the upper limit of normal range but without
complete normalization was considered as a partial response to cabergoline. Patients with UFC
≥125% of the upper limit of normal range were classified as non-responders. A re-increase in
UFC over the upper limit of normal range after initial normalization with cabergoline was
considered an escape to treatment.
STATISTICAL ANALYSIS

Data for UFC are presented as means ± SD and percentage of upper limit of normal. Student t-test was used to compare baseline and post-treatment values. Statistical significance was defined as p-values <0.05.

RESULTS

Initial response to treatment

Within 3-6 months of therapy, complete response of UFC was achieved in 11 patients (36.6%) and partial response in 4 patients (13.3%), representing 50% of the cohort. Mean cabergoline dose used was 1.5 mg/wk with a range from 0.5 to 4.0 mg/wk. Complete normalization of UFC in full responders took an average of 4.2 months with the progressive increase of cabergoline doses.

Fifteen subjects were unresponsive to cabergoline treatment with minimal change in UFC and persistent symptoms and signs of CD. For the non-responders, UFC tended to increase by a mean of 35.2% during cabergoline use with an average dose of 2.0 mg/wk (range of 1.0 to 4.5 mg/wk); in this subgroup, cabergoline was used for a mean of 4.0 months (from 1 to 9 months).

For the three subjects in whom cabergoline was used as first line therapy, one patient demonstrated a complete normalization of UFC after 1 month of treatment with 1.0 mg/wk of cabergoline. This subject is still in full response for UFC with regression of clinical signs for a total of 18 months of treatment with a current dose of 0.5 mg/wk. The dose of cabergoline was reduced to limit possible adrenal insufficiency. The two other patients on first-line therapy did not respond after 3 months of treatment with 1.5 or 2.0 mg/wk of cabergoline.
Long-term response to treatment

At final analysis, 9 of the initial 11 full responders maintained a eucortisolic state after a mean duration of 37 months of treatment (from 12 to 60 months) with a mean dose of 2.1 mg/wk of cabergoline (range from 0.5 to 6.0 mg/wk) (fig. 1). Clinical symptoms and signs of CD regressed progressively in full responders. An escape phenomenon was observed in two patients with initial complete normalization of UFC after 2 years of treatment with 2.5 mg/wk and after 5 years with 1.5 mg/wk of cabergoline respectively (fig. 2). In the second subject, increasing the cabergoline dose up to 6.0 mg/wk restored normal values of UFC after 78 months of treatment, but UFC recently increased again to 136% of normal after 84 months. This patient’s pituitary macroadenoma regressed by more than 50% with the initial 1.5 mg/wk dose of cabergoline; a regrowth of the macroadenoma occurred during the escape phenomenon but decreased in size again following increase of cabergoline to 6.0 mg/wk dose (31). Partial response to cabergoline was noted initially in 4 subjects but after 6 months of treatment these 4 patients increased their UFC over 125% of the upper limit of normal range, even if, for 2 cases, cabergoline doses were increased. However, the average dose used in those cases was only of 2.0 mg/wk.

Including the two subjects with late escape phenomenon as failures, long-term and complete response to cabergoline was achieved in 30% of our cohort with a mean dose and length of treatment of 2.1 mg/wk over 37 months. In our study population, neither initial size of tumor, timing of cabergoline introduction (prior to surgery or rapidly after the intervention), ACTH levels nor the initial severity of hypercortisolism was predictive of the response. No difference was noted in UFC before starting cabergoline therapy between the three outcome groups, with a mean UFC of 243% for patients with an initial complete response to cabergoline, 262% for partial responders and 317% for non responders (p>0.05). Detailed appreciation of
cabergoline effect on tumor growth was not possible since the majority of patients of this cohort did not have measurable residual adenomas on MRI following surgery.

Prolactin was suppressed with cabergoline treatment in all patients in whom it was monitored. The three patients with initial hyperprolactinemia (twice the upper limit of normal) did not achieve normalization of UFC with cabergoline therapy.

TOLERANCE TO CABERGOLINE THERAPY

No major adverse events or side effects were reported. Transient dizziness and nausea were noted during initiation of cabergoline therapy in three patients but did not require drug withdrawal. No symptoms of cardiovascular dysfunction were reported during the period of treatment. During their follow-up, eight patients had an echocardiography performed and none demonstrated the presence of significant cardiac valvulopathy. No patient presented symptomatic adrenal insufficiency secondary to cabergoline therapy.

DISCUSSION

The present study confirms that short-term treatment of patients with CD with cabergoline improves cortisol secretion in 50% of subjects, with complete normalization of UFC in 36.6% of cases. Long-term follow-up during a mean period of 37 months demonstrated sustained effectiveness of cabergoline in 30% of subjects with mostly persistent or recurrent CD. Only two patients with initial complete response presented an escape phenomenon but only after 2.5 and 5 years of treatment. Restoration of a complete response by increasing the dose of cabergoline was possible only transiently in one of the two patients, but her last UFC value increased slightly above normal range. In subjects with incomplete initial response to
cabergoline (first 3-6 months), extension of treatment to over one year did not achieve complete or sustained normalization of UFC.

Our results are similar to those reported by the group of Pivonello et al. (30) who demonstrated a sustained response to cabergoline in 40% of subjects over a mean period of treatment of 24 months with an average dose of 3.5 mg/wk (range from 1-7 mg/wk). In their study, initial response to cabergoline was even higher as they found complete normalization of cortisol secretion in 15 of their 20 patients (75%) after 3 to 6 months of treatment. Their escape rate was higher than that observed in our study; however our finding of a 30% complete response rate after a mean of 37 months of therapy and in some cases maintained for more than 60 months clearly extends the demonstration of long-term efficacy of cabergoline in selected patients with CD. It should be noted that 40% of their subjects demonstrated initial mild hyperprolactinemia (30), but we found no correlation between basal prolactin levels and response of UFC to cabergoline therapy in our study. The more modest 25% complete response rate in CD patients studied by Vilar et al. (29) could result from their maximal cabergoline dose of 3.0 mg/week.

We used cabergoline as first line therapy in only three patients of the cohort. One subject still presents a complete response to cabergoline and stabilization of the microadenoma on MRI. There is only very limited data about cabergoline as first line therapy in CD, but its safety profile, relative efficacy and surgery-sparing potential appears to warrant the conduct of prospective studies on its long-term efficacy in larger cohorts of patients with CD; it could be a particularly interesting first-line therapeutic option for patients with radiologically non detectable CD.
There are several limitations of the present report which are mostly related to its design as a retrospective study without a systematic therapeutic and monitoring protocol. Thus, a maximal dosage of 6.0 mg/wk was not reached in over 80% of patients with initial partial or non response to cabergoline, potentially underestimating the maximal efficacy of cabergoline therapy. Even if full response to cabergoline occurred at a low dose in some subjects, an increase in the dose of cabergoline became necessary in other patients in whom UFC escaped after initial response (patient no 11 in fig. 2). Larger number of patients will be required to establish a possible relationship between degree of hypercortisolism, cabergoline dosage and response to treatment. Cyclic CD could also be considered to explain fluctuations in UFC and required dose of cabergoline to control CD; however in our two patients with an escape phenomenon, this appears unlikely when considering the initial length of response lasting two and five years. It is more likely that the escape phenomenon would result form progressive selection and growth of corticotroph cells not expressing high levels of D2-receptors. In this report two distinct populations of patients in two countries were studied and UFC were measured in different laboratories but, for each subject, the same assay and laboratory was used for their serial UFC.

One main concern about cabergoline utilization is its potential side effects. No major hypotension or severe asthenia reported in previous studies (30,32) were documented among patients in this cohort. Even if all patients of this cohort did not systematically undergo an echocardiography before and during therapy, none of the subjects evaluated during longer successful use of cabergoline developed echocardiographic evidence of cardiac dysfunction or valvulopathy. Recent studies found that patients with Parkinson’s disease treated with cabergoline had an increased prevalence of cardiac valve insufficiency (33,34). However, higher doses of cabergoline were used in Parkinson’s disease patients, an older population than patients
with CD. The length of therapy in this study is also shorter compared to long-term treatment used in Parkinson disease and could explain the lack of valvular disease in our group and in the 20 patients with CD reported by Pivonello et al. (30). Longer-term follow-up to evaluate the risk of development of valvulopathy is thus indicated.

Cabergoline was described as having potential positive metabolic effects. Similarly to other dopamine receptor agonists, it could lower blood pressure and improve glucose tolerance independently of its cortisol lowering effect. Dopamine agonists lower peripheral resistance, relaxing vascular wall smooth muscles, with consequent improvement of blood pressure (32). Also, bromocriptine improved glucose homeostasis in type 2 diabetes patients, by stimulating splanchnic glucose reuptake and by helping insulin-mediated suppression of hepatic glucose production (35).

Recent studies have also demonstrated a predominance of somatostatin receptor subtype 5 (sstr5) in corticotroph adenomas as well as co-expression of dopamine receptors in some tumors; pasireotide, a multi-somatostatin receptor analog, was found to inhibit ACTH secretion from corticotroph adenomas in vitro (36). Recently, Boscaro et al. showed that short-term 15-day administration of pasireotide improved or normalized UFC in 76% of patients with de novo or persistent CD (37); the long-term effects of this drug is currently under investigation, but appears to have potential long-term efficacy (38). In a proof-of-concept pilot study, Feelders et al. (39) recently found that the sequential combination of low-dose pasireotide, followed, if UFC remained elevated, by cabergoline up to 4.5 mg/wk during 80 days could achieve a 53% of complete response rate in a group of 17 patients with de novo CD; the sequential addition of ketoconazole if UFC remained elevated achieved normalization of UFC in 88% of patients.
In conclusion, our study confirms that cabergoline is a valid therapeutic option as it provides long-term complete response in 30% of patients mostly with persistent or recurrent CD and presents a reassuring safety profile. Additional prospective studies with larger number of patients are needed to corroborate those conclusions and to validate predictive factors for the identification of patients susceptible to respond to cabergoline. Further studies using cabergoline in monotherapy or in combination with pasireotide should provide exciting new strategies for medical treatment of de novo or recurrent CD.
DECLARATION OF INTEREST

For the present research, there is no conflict of interest that could be perceived as prejudicing its impartiality.

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REFERENCES


Figure 1: Complete long-term response to cabergoline monotherapy in nine patients with CD

Figure 2: Detailed response to cabergoline in 2 patients with CD who presented an escape phenomenon
Table 1: Clinical and biochemical profile of 30 patients with CD before and after therapy with cabergoline

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Mean UFC in full responders 243

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Mean UFC in non responders 317

| Mean | 39 25F 5M | Mean UFC in non responders 317 | 30% of complete response |

CD: Cushing’s disease; UFC: urinary free cortisol; NV: normal value; Pt: patient; PRL: prolactin; Yr: year; F: female; M: male; TS: transsphenoidal surgery; Keto: ketoconazole; Caber: cabergoline as first line; Vasc: vascular; Arach: arachnoidocele; Rotx: radiotherapy.

* Decreased prolactin secondary to partial hypopituitarism after initial TS surgery in this patient. ** No lesion detected on MRI.
Figure 1: Complete long-term response to cabergoline monotherapy in nine patients with CD
Figure 2: Detailed response to cabergoline in 2 patients with CD who presented an escape phenomenon.