Characterization and Quantitation of Antiestrogen Binding Sites in Estrogen Receptor-positive and -negative Human Breast Cancer Cell Lines

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ABSTRACT

Antiestrogens are useful in the treatment of endocrine-responsive breast cancers in humans. In an attempt to understand the mechanisms underlying their estrogen antagonism and antitumor character, we have examined the interaction of antiestrogens with three human breast cancer cell lines that differ markedly in their estrogen receptor content and in their sensitivity to growth suppression by antiestrogens. MCF-7 cells have high levels of estrogen receptor, and their growth is inhibited markedly by antiestrogens; T47D cells contain low levels of estrogen receptor, and their growth is suppressed weakly by antiestrogens; and MDA-MB-231 cells contain no detectable estrogen receptors, and their growth is unaffected by antiestrogens. In addition to binding to the estrogen receptor, antiestrogens are found to be associated with binding sites that are distinct from the estrogen receptor. These estrogen-noncompeetible but antiestrogen-competible binding sites are present in the 800 and 12,000 x g supernatants of all three breast cancer cells. The antiestrogen binding sites are pelleted upon centrifugation at 100,000 or 180,000 x g and appear to be associated with microsomal membranes, while the majority of the estrogen receptor remains soluble at all centrifugation speeds. Although these cells differ markedly in their estrogen receptor content and sensitivity to growth inhibition by the antiestrogen, tamoxifen, all three cell lines contain similar quantities of estrogen-noncompeetible antiestrogen binding sites (MCF-7 cells, 390 ± 50 (S.E.); T47D cells, 360 ± 50; and MDA-MB-231 cells, 260 ± 50 fmol/mg protein) that have a similar affinity (Kd = 2 to 4 nm) for tamoxifen. The affinity of a series of antiestrogens and related compounds for these antiestrogen sites follows the order cis-tamoxifen > α-|p-|2-[1-pyridinyl]ethoxy|phenyl|α-4-methoxy-α'-nitrostilbene (CI628) > trans-tamoxifen = trans-hydroxytamoxifen > α-|p-|2-[1-pyridinyl]ethoxy|phenyl|4-hydroxy-α'-nitrostilbene (CI628M) > 6-hydroxy-2-(p-hydroxyphenyl)benzo[b]thien-3-yl-p-[2(1-pyridinyl)]ethoxy|phenyl ketone (LY117018). This order of affinities of different antiestrogens for the estrogen receptor correlates well with their potency in inhibiting tumor cell growth (8, 10, 34). Hence, the estrogen antagonism of antiestrogens appears to be mediated, at least in large part, by antiestrogen interaction with the estrogen receptor system. Recently, it has been reported that triphenylethylene compounds also bind to additional saturable sites present in the cytosol of rat and guinea pig uterus, chick oviduct, and human breast cancers (12, 15, 28, 36–39). These sites are distinct from the estrogen receptor and are most readily distinguishable by the fact that they bind triphenylethylene antiestrogens but, in contrast to the estrogen receptor, they do not bind steroidal or nonsteroidal estrogens (38). These sites have been termed “antiestrogen-specific” or “estrogen-noncompeetible” binding sites. Since these sites are present in estrogen target tissues which are responsive to antiestrogen, they could be important in mediating and/or modulating the actions of antiestrogens.
we have studied the distribution, quantities, and binding characteristics of these sites in 3 human breast cancer cell lines that differ in their estrogen receptor content and in their sensitivity to growth suppression by antiestrogens: MCF-7 cells contain high levels of estrogen receptor, and their growth is inhibited markedly by antiestrogens; T47D cells contain low levels of estrogen receptor, and their growth is inhibited weakly by antiestrogens; and MDA-MB-231 cells contain no detectable estrogen receptors, and their growth is unaffected by antiestrogens. Our results show that, despite marked differences in the responsiveness of these cells to growth inhibition by the antiestrogen, tamoxifen (1-[4-(2-dimethylaminoethoxy)phenyl]-1,2-diphenylbut-1-[Z]-ene), all 3 cell lines possess similar quantities of estrogen- 


testable, antiestrogen binding sites with similar affinities for tamoxifen. In addition, the subcellular distribution of these antiestrogen binding sites and the relative binding affinities of various antiestrogens for these sites are similar in the 3 cell lines. These findings raise questions about the role of these sites in mediating directly the estrogen antagonistic effects of antiestrogens in breast cancer cells.

MATERIALS AND METHODS

Chemicals. The pure trans isomer of [3H]tamoxifen (12.2 Ci/mmol) used to assay the antiestrogen binding sites was synthesized by Dr. D. Robertson and Dr. J. Katzenellenbogen (32), University of Illinois, Urbana, Ill. Estrogen receptor content was assayed with [3H]estradiol (54 Ci/mmol) from New England Nuclear (Boston, Mass.). The nonradioactive antiestrogens, trans-tamoxifen and trans-4-hydroxytamoxifen (1-[4-(2-dimethylaminoethoxy)phenyl]-1,4-hydroxyphenyl), 2'-phenylbut-1-[Z]-ene), and the estrogen, cis-tamoxifen (ICI 47,699), were from ICI Americas, Inc. (Wilmington, Del); C1628 was from Parke-Davis & Co. (Ann Arbor, Mich.); U23, 469, cie-[3-[1,2,3,4-tetrahydro-6-methoxy-2-phenyl]-1-naphthylphenoxyl]-1,2-propanediol] was from Upjohn Co. (Kalamazoo, Mich.); and LY117018 was obtained from Eli Lilly & Co. (Indianapolis, Ind.). The demethylated derivative of C1628, designated C1628M, was synthesized by Dr. D. Robertson and Dr. J. Katzenellenbogen (23). All media, sera, and antibiotics used to culture the cells were obtained from Grand Island Biological Co. (Grand Island, N. Y.). Insulin, hydrocortisone, estradiol, progesterone, testosterone, dihydrotestosterone, and diethylstilbestrol were purchased from Sigma Chemical Co. (St. Louis, Mo.).

Cells and Culture Conditions. MCF-7 cells were obtained from Dr. Charles McGrath of the Michigan Cancer Foundation (Detroit, Mich.) and were grown in plastic T-150 flasks in Eagle's minimal essential medium supplemented with 10% FBS, 2 mM glutamine, 1% piperazineethanesulfonic acid buffer, gentamicin (50 μg/ml), penicillin (100 units/ml), streptomycin (100 μg/ml), insulin (1.5 ng/ml), hydrocortisone (3.75 ng/ml), and 5% calf serum that had been treated with dextran-coated charcoal for 45 min at 55°C to remove endogenous hormones (CDS) (10).

The T47D and MDA-MB-231 cells were obtained from EG & G Mason Research Institute (Worcester, Mass.). Medium for the T47D cells was the same as for the MCF-7 cells except that the serum was 5% charcoal-treated fetal calf serum. The MDA-MB-231 cells were grown in Leibovitz's Medium L-15 supplemented with all of the additives used in the MCF-7 cell medium plus glutathione (16 mg/liter) and 5% calf serum that was not charcoal treated.

Cell Growth Experiments. To determine the effect of tamoxifen on breast cancer cell growth, MCF-7 cells were seeded into T-25 flasks (1.5 x 10^6 cells/flask) and grown for 2 days in medium supplemented as described above. After this time, cells from 2 flasks were harvested and counted with a Coulter Counter as described by Butler et al. (7) (Day 0). The medium was then changed to Eagle's minimal essential medium supplemented as described above except containing 2% CDCS and tamoxifen (10^-8 M) or ethanol vehicle (0.1%). At several time points during the 12-day growth period, triplicate flasks of cells were counted. The procedure was similar for the T47D and MDA-MB-231 cells. T47D cells (seeded at 3 x 10^6 cells/flask) were grown in regular culture medium throughout the growth period. MDA-MB-231 cells (seeded at 0.5 x 10^6/flask) were grown in Leibovitz's Medium L-15 supplemented as described above but containing 2% CDCS.

Binding Studies. The cells from nearly confluent T-150 flasks were harvested by incubating cells at 37°C for about 10 min in Hanks' balanced salt solution (calcium and magnesium free; Grand Island Biological Co.) with 1 mm EDTA. The cells were washed twice with a buffer of either 5 M sodium phosphate-10 mM thioglycollate-10% glycerol, pH 7.4, or TEA and homogenized in a Dounce homogenizer (40 to 50 strokes with a B-T pestle).

In preliminary studies, the subcellular localization of the antiestrogen binding sites was determined by centrifuging MCF-7 cell homogenates at either 800 x g for 10 min; 12,000 x g for 30 min; or 100,000 x g for 60 min. In subsequent fractionation experiments, cell homogenates were sequentially centrifuged at 800, 12,000, and 180,000 x g. The 12,000 and 180,000 x g pellets were resuspended in buffer and thoroughly homogenized with a Kontes glass-glass homogenizer. For the Scatchard analysis and competition studies, the 12,000 x g supernatant was used.

The concentration of antiestrogen binding sites was determined by incubating 250 μl of cell supernatant or resuspended pellet with 5 μl of 150 nM [3H]tamoxifen in dimethylformamide and with 5 μl of ethanol or 10^-4 M estradiol in 5 μl of ethanol. After a 30-min preincubation at 0°C to fill estrogen receptor sites, samples were diluted with 220 μl of TEA buffer prior to the addition of 20 μl of competitor in dimethylformamide as described previously (36). Samples were incubated for 16 hr at 0°C, and then 88 μl of dextran-coated charcoal (5% Norit A and 0.5% dextran in TEA buffer) was added. The charcoal was pelleted by centrifuging at 12,800 x g for 10 min, and an aliquot of the supernatant was removed for determination of bound radioactivity.

Estrogen receptor content was assayed in similar incubations containing 10^-8 M radiolabeled estradiol in the presence and absence of 10^-4 M unlabeled estradiol for 16 hr at 0°C and with dextran-charcoal as described above.

Enzyme Assays and Protein and DNA Determinations. The microsomal marker enzyme, glucose-6-phosphatase, was assayed by the method of Hubscher and West (20). Acid phosphatase which served as a lysosomal marker enzyme was assayed as described by Szego et al. (40). The P, liberated in these assays was analyzed using a kit for the colorimetric determination of inorganic phosphorus (Sigma). Glucose-6-phosphate dehydrogenase, a soluble cytoplasmic marker, was assayed by the method of Glock and McLean (14). Protein was determined by the method of Peterson (31). DNA was assayed by the diphenylamine reaction (6).

RESULTS

Subcellular Localization of Antiestrogen Binding Sites. Although other investigators have reported that estrogen-noncompetitive binding of the antiestrogen, tamoxifen, occurs in cytosol preparations from MCF-7 cells (28, 39), we had always found antiestrogen and estrogen binding in cytosol to be nearly mutually competitive (9); we, therefore, found little evidence for antiestrogen-specific binding sites in our high-speed MCF-7 cytosol preparations. However, when we undertook subcellular fractionation studies, we found that substantial amounts of estrogen-noncompetitive, antiestrogen binding sites do exist in low-speed supernatants.
When tamoxifen binding was investigated in homogenates of MCF-7 cells centrifuged at different speeds for various periods of time, "antiestrogen-specific" binding sites were present in the 800 and 12,000 × g for 30 min low-speed supernatants of cell homogenates, but were pelleted upon centrifugation at 100,000 or 180,000 × g for 60 min (Chart 1). Chart 1 shows the results of assays in which a trace amount of tritiated tamoxifen (1.5 nM) was incubated in the presence of increasing concentrations of unlabeled estradiol or unlabeled tamoxifen (after a 30-min pre-treatment with 10⁻⁴ M estradiol to occupy estrogen receptors sites fully). The difference between the estradiol curve and the tamoxifen plus 10⁻⁴ M estradiol curve is considered to represent the estrogen-noncompetitive, but antiestrogen-competitive ("antiestrogen-specific") binding sites. The subcellular fractionation pattern for "antiestrogen-specific" sites differs from that of the estrogen receptor (Chart 1, right of each panel) which remained soluble at all centrifugation speeds. However, the 100,000 and 180,000 × g supernatant fractions and, therefore, some estrogen receptors may be pelleted at the higher centrifugation speeds (as noted by others for estrogen and androgen receptors) (25, 30).

It is important to note that, since the different subcellular fractions contain a different proportion of "antiestrogen-specific" binding sites and estrogen receptor sites, the distribution of the tritiated tamoxifen between these sites varies in the different supernatant preparations. Hence, the apparent increase in effectiveness of estradiol in competing for tritiated tamoxifen binding (estradiol curves) in the 100,000 and 180,000 × g supernatant preparations is most probably attributable to the relative increase in estrogen receptor content versus antiestrogen binding sites and nonspecific binding, and not to an increase in the affinity of tamoxifen for the receptor.

In an attempt to define the subcellular localization of antiestrogen binding sites, MCF-7 cell homogenates were ultracentrifuged sequentially, and the supernatant fractions and resuspended pellets were assayed for marker enzyme activities and for antiestrogen binding site and estrogen receptor content. The results of these studies are presented in Chart 2. When the 800 × g supernatant fraction is centrifuged for 30 min at 12,000 × g, over 80% of the antiestrogen binding sites and estrogen receptors remain soluble as does the soluble cytoplasmic marker, glucose-6-phosphate dehydrogenase. Approximately half of the microsomal marker, glucose-6-phosphatase, and the lysosomal marker, acid phosphatase, were pelleted during this centrifugation. When the 12,000 × g supernatant is subsequently centrifuged at 180,000 × g for 1 hr, virtually all of the antiestrogen binding sites and a portion of the microsomal marker activity are
pelleted. In contrast, most of the estrogen receptors and the soluble enzyme marker, glucose-6-phosphate dehydrogenase, remain in the 180,000 × g supernatant. The specific activity (sites/unit protein) of the antiestrogen sites is enriched in the 180,000 × g pellet (Chart 2B). Since the antiestrogen binding sites are pelleted by centrifugation at 180,000 × g for 60 min, they may be associated with the microsomal membranes. There is, however, little of the total activity (Chart 2A) of the microsomal marker enzyme, glucose-6-phosphatase, in the 180,000 × g for 60 min pellet. This enzyme and the lysosomal marker enzyme, acidic phosphatase, are found predominantly in the 12,000 × g for 30 min pellet. The separation of the microsomal marker enzyme and antiestrogen binding sites, which also appear to be particulate, suggests that these 2 components may be located in different areas of the microsomal membranes which are known to be heterogeneous (1).

**Antiestrogen Inhibition of Growth of Breast Cancer Cells and Antiestrogen Binding Sites in Different Breast Cancer Cell Lines.** To determine if antiestrogen binding sites are present in other breast cancer cell lines, we examined tamoxifen binding in T47D and MDA-MB-231 cells as well as in MCF-7 cells. These 3 cell lines differ markedly in their estrogen receptor content and in their responsiveness to antiestrogen (Chart 3). Tamoxifen inhibited growth was greatest in MCF-7 cells which we find to contain approximately 7 pmol of estrogen receptor/mg DNA. In T47D cells, estrogen receptor levels were 10 to 15% of the values determined for MCF-7 cells (data not shown), and tamoxifen decreased growth, but far less than in MCF-7 cells. No estrogen receptor was detected in MDA-MB-231 cells, and tamoxifen did not alter growth in these cells. Hence, tamoxifen inhibited growth only in those cell lines that contained estrogen receptor, i.e., MCF-7 and T47D cells, and the magnitude of growth suppression appears to be related to the estrogen receptor content of the cells.

In contrast to the differences observed in estrogen receptor levels and in responsiveness to tamoxifen among these 3 cell lines, the concentration of estrogen-noncompetitive antiestrogen binding sites and their affinity for tamoxifen were found to be similar in the 3 cell lines (Table 1 and Chart 4). Chart 4 shows the results of a typical competitive binding experiment in which a trace amount of tritiated tamoxifen (1.5 nm) was incubated in the presence of increasing concentrations of unlabeled estradiol or unlabeled tamoxifen (after a 30-min pretreatment with 10⁻⁶ M estradiol to fully occupy estrogen receptors). Values have been normalized per mg protein. These data are also replotted in the form of a Scatchard plot (Chart 4, lower panels) where 1/Kd values of 2 to 4 nm are obtained for the binding of tamoxifen. As shown in Table 1, which summarizes data from 3 competitive binding experiments with each cell line, the antiestrogen-specific binding sites are present at approximately the same concentration in the 3 cell lines, and the affinity of tamoxifen for these sites is likewise similar in all of the cell lines.

**Antiestrogen Binding Sites in Breast Cancer Cells**

Table 1

<table>
<thead>
<tr>
<th>Cell</th>
<th>Site concentration* (fmol/mg protein)</th>
<th>Kd (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCF-7</td>
<td>390 ± 50</td>
<td>3.7 ± 0.9</td>
</tr>
<tr>
<td>T47D</td>
<td>360 ± 50</td>
<td>3.6 ± 0.9</td>
</tr>
<tr>
<td>MDA-MB-231</td>
<td>260 ± 50</td>
<td>3.4 ± 0.7</td>
</tr>
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* Concentration of estrogen-noncompetitive, antiestrogen binding sites measured in the 12,000 × g for 30 min supernatant fraction.

† Mean ± S.E. from 3 separate experiments with each cell line.

**Chart 4.** Evaluation of the presence and levels of "antiestrogen-specific" binding sites in 3 different human breast cancer cell lines. Cells were homogenized, and the 30-min 12,000 × g supernatant was incubated with 1.5 nm [³H]tamoxifen alone (O), [³H]tamoxifen with increasing (10⁻¹⁰ to 10⁻¹⁴ M) concentrations of estradiol (E₂), or [³H]tamoxifen plus 10⁻⁶ M estradiol for 30 min at 0° to fill estrogen receptor sites (•) prior to addition of tamoxifen (Tam; 10⁻¹⁰ to 10⁻⁴ M, #). Incubations were maintained for 18 hr at 0° prior to charcoal-dextran treatment. Values for [³H]tamoxifen-bound radioactivity were normalized for protein concentration of the cell supernatants (all about 1.2 to 1.6 mg protein per ml) and are expressed as fmol [³H]tamoxifen bound per mg protein. In lower panels, data on antiestrogen binding are analyzed by Scatchard plot analysis from which the Kd and number of sites were calculated.

**Ligand Binding Specificity of Antiestrogen Binding Sites.** Competitive binding assays were used to determine the affinities of various antiestrogens and related compounds for the "antiestrogen-specific" binding sites. As seen in Chart 5 and Table 2, these sites are specific for compounds which are triphenylethylene derivatives. None of the steroids (estradiol, hydrocortisone, progesterone, dihydrotestosterone, or testosterone) nor the nonsteroidal estrogen, diethylstilbestrol, competed with [³H]tamoxifen for binding to these sites. The order of competitive effectiveness is cis-tamoxifen > CI628 > trans-tamoxifen = trans-hydroxytamoxifen > CI628M > LY117018. Chart 5 also shows that the competitive binding curves are parallel for all of the triphenylethylene compounds tested. The competition curve for LY117018 has a somewhat shallower slope, suggesting that interaction of LY117018 with these antiestrogen sites may be

![Chart 3](chart3.png)

Effect of tamoxifen (Tam; 10⁻⁶ M) on the growth of 3 different human breast cancer cell lines. MCF-7 cells, T47D cells, and MDA-MB-231 cells. Cells were grown in the continuous presence of tamoxifen, and media with fresh tamoxifen were renewed every other day. On the days indicated, triplicate flasks of cells were counted. Values are means of the triplicate determinations. Bars, S.E.

![Chart 4](chart4.png)

Antiestrogen binding sites in human breast cancer cells.
of tamoxifen and other triphenyl ethylene compounds.
The competition curve with LY117018 was shallower than that of tamoxifen, but cis-tamoxifen has no greater affinity for these sites than that of trans-tamoxifen, and CI628M and trans-hydroxytamoxifen, which are more structurally related to tamoxifen, are qualitatively different from that of tamoxifen and compounds structurally related to tamoxifen.

The relative binding affinities of the various triphenyl ethylene and related compounds for these antiestrogen sites do not parallel the potency of these compounds as antiestrogens or their affinity for the estrogen receptor (Table 2). For example, the affinity of cis-tamoxifen for this binding site is about 2-fold greater than that of trans-tamoxifen, but cis-tamoxifen has no antiestrogenic effects and is only a weak estrogen in MCF-7 cells8 (8) and in rat uterus (16, 21, 33). In addition, LY117018 is a very potent antiestrogen (2, 3, 34) but binds weakly to these antiestrogen sites. As in MCF-7 cells, these 2 binding components can be readily distinguished by differences in ligand specificity, fractionation pattern, and protease and heat sensitivity (36).

The antiestrogen binding sites we find in the 3 breast cancer cell lines appear to be similar to the antiestrogen binding sites described in rat tissues. We have recently reported that high-affinity (Kd 1 to 3 nM) estrogen-noncompetitive antiestrogen binding sites are present in the 12,000 × g for 30 min supernatants of estrogen receptor-positive (uterus, ovary, liver, and brain) as well as estrogen receptor-negative (esophagus, lung, and spleen) rat tissues (36). In the immature rat uterus, the antiestrogen binding site content is about one-tenth that of the estrogen receptor. As in MCF-7 cells, these 2 binding components can be readily distinguished by differences in ligand specificity, fractionation pattern, and protease and heat sensitivity (36).

As reported by Sutherland et al. (38), the antiestrogen binding sites are specific for compounds with a triphenyl ethylene structure.

**DISCUSSION**

The results of our studies demonstrate that antiestrogen binding sites distinct from the estrogen receptor are present in the MCF-7, T47D, and MDA-MB-231 breast cancer cell lines. The concentration of the antiestrogen binding sites and their affinity for tamoxifen are similar in the 3 breast cancer cell lines, although the concentration of estrogen receptor and the sensitivity of the cells to growth suppression by tamoxifen are markedly different. In MCF-7 cells, the concentrations of estrogen receptor and “antiestrogen-specific” binding sites are approximately equal while, in T47D cells, the concentration of receptor is only one-eighth that of the antiestrogen sites. These 2 binding components are, however, readily distinguishable because: (a) the ligand binding specificities of the estrogen receptor and antiestrogen sites are very different; (b) the binding capacity of the estrogen receptor is destroyed by heating for 60 min at 37°, while the antiestrogen sites are stable to this treatment (data not presented); and (c) the antiestrogen binding sites are pelleted by centrifugation at 180,000 × g for 60 min, whereas much of the estrogen receptor remains soluble.

The antiestrogen binding sites in human breast cancer cell lines appear to be similar to the antiestrogen binding sites described in rat tissues. We have recently reported that high-affinity (Kd 1 to 3 nM) estrogen-noncompetitive antiestrogen binding sites are present in the 12,000 × g for 30 min supernatants of estrogen receptor-positive (uterus, ovary, liver, and brain) as well as estrogen receptor-negative (esophagus, lung, and spleen) rat tissues (36). In the immature rat uterus, the antiestrogen binding site content is about one-tenth that of the estrogen receptor. As in MCF-7 cells, these 2 binding components can be readily distinguished by differences in ligand specificity, fractionation pattern, and protease and heat sensitivity (36).

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**Table 2**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Estrogen receptor (estradiol = 100%)</th>
<th>Antiestrogen binding sites (trans-tamoxifen = 100%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>trans-Tamoxifen</td>
<td>2 ± 0.56</td>
<td>100</td>
</tr>
<tr>
<td>cis-Tamoxifen</td>
<td>0.2 ± 0.1</td>
<td>267 ± 20</td>
</tr>
<tr>
<td>CI628</td>
<td>3 ± 2</td>
<td>156 ± 7</td>
</tr>
<tr>
<td>trans-Hydroxytamoxifen</td>
<td>167 ± 20</td>
<td>110 ± 8</td>
</tr>
<tr>
<td>CI628M</td>
<td>115 ± 26</td>
<td>19 ± 6</td>
</tr>
<tr>
<td>LY117018</td>
<td>100</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Progesterone</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Testosterone</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

8 All values determined by competitive binding assays using [3H]estradiol or [3H]tamoxifen for measurement of estrogen receptor or antiestrogen sites, respectively.

6 Mean ± S.E. of 3 determinations.

* The competition curve with LY117018 has a shallower slope than that of trans-tamoxifen. This value has been determined from the concentration giving 50% competition.

tecture. The affinity of different antiestrogens for these sites does not, however, correlate with their potency as antiestrogens. For example, cis-tamoxifen binds to these sites with twice the affinity of trans-tamoxifen but displays no estrogen-antagonistic properties (16, 21, 33). Other compounds (i.e., LY117018 and CI628M) show high antiestrogen potency and high estrogen receptor affinity (4, 9, 23, 34) but low or reduced affinity for the antiestrogen sites. Because these sites also have affinity for compounds that are estrogens (e.g., cis-tamoxifen), it is not fully appropriate to consider these as "antiestrogen-specific" binding sites.

Although the antiestrogen binding sites are present in all 3 cell lines, only those cells which contained estrogen receptors showed growth inhibition following tamoxifen treatment. This result, coupled with the finding that the affinity of antiestrogens for these sites does not parallel antiestrogenic potency, suggests that antiestrogen binding to these sites probably does not mediate the effects of antiestrogens on cell growth.

While our data shed doubt on the role of these antiestrogen sites in the growth suppression evoked by antiestrogens, it is conceivable that a defect in a biochemical process that occurs after tamoxifen binding to the antiestrogen sites could account for the tamoxifen resistance of cells, such as the MDA-MB-231 cells, that contain antiestrogen binding sites but do not display growth inhibition by tamoxifen. Surely this is possible, since there is clear evidence for the presence of estrogen receptors in some human breast cancers that are unresponsive to estrogens and antiestrogens (26, 29). In addition, Faye et al. (11) have presented evidence for a variant of MCF-7 cells that appears to have lost the antiestrogen binding site and sensitivity to growth inhibition by tamoxifen while retaining estrogen receptor activity.

Nevertheless, the presence of antiestrogen binding sites in antiestrogen-responsive and -nonresponsive breast cancer cells as shown here, as well as in many rat tissues (36, 38), suggests that these sites are probably not mediating directly the estrogen antagonism of antiestrogens. These sites may represent binding sites for other natural ligands for which the triphenylethylene compounds bear a structural resemblance. While the natural ligands for these sites and the physiological importance of these sites is not known presently, it seems likely that these sites might alter the distribution and pharmacokinetics of antiestrogens in vivo and might mediate effects of antiestrogens unrelated to estrogen antagonism. Studies in our laboratory are continuing in an attempt to determine the physiological role of these sites and their role in the action of antiestrogens.

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REFERENCES


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