Signatures of Breast Cancer Metastasis at a Glance
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**Biomarkers of breast cancer metastasis derived from gene expression profiling**

<table>
<thead>
<tr>
<th>Gene Signature (Biological(Functional))</th>
<th>Primary tumor biopsies from metastatic patient</th>
<th>Number of alterations for genes associated with breast cancer</th>
<th>Gene expression levels from metastatic samples</th>
<th>Number of alterations for genes associated with breast cancer</th>
<th>Cancer cell biology and metastasis</th>
<th>Role of gene in breast cancer progression</th>
<th>Clinical correlation with breast cancer progression</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRCA1, BRCA2, CHEK2, and TP53</td>
<td>3,678 alterations in breast cancer biology</td>
<td>1,000 alterations in metastatic breast cancer biology</td>
<td>500 alterations in breast cancer biology</td>
<td>500 alterations in metastatic breast cancer biology</td>
<td>BRCA1 and BRCA2 are associated with breast cancer and metastasis.</td>
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</tr>
</tbody>
</table>

**Metastasis pathways**

1. **Nanoparticle transport**
   - Enhanced nanoparticle transport through the bloodstream.
   - Increased expression of genes involved in nanoparticle transport.

2. **Chemokine signaling**
   - Increased expression of chemokine receptors.
   - Increased chemokine production.

3. **Fibroblast activation**
   - Increased expression of fibroblast activation markers.
   - Increased fibroblast proliferation.

4. **Matrix remodeling**
   - Increased expression of matrix-degrading enzymes.
   - Increased matrix remodeling.

5. **Angiogenesis**
   - Increased expression of angiogenic factors.
   - Increased angiogenesis.

**Clinical applications**

<table>
<thead>
<tr>
<th>Test</th>
<th>Assay</th>
<th>Platform</th>
<th>Risk stratification</th>
<th>Patient population</th>
</tr>
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<tbody>
<tr>
<td>BRCA1</td>
<td>BRCA1</td>
<td>PCR</td>
<td>BRCA1 mutational status</td>
<td>BRCA1-positive patients (Hereditary Breast and Ovarian Cancer Syndrome)</td>
</tr>
</tbody>
</table>

**Role of Mena**

<table>
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<tr>
<th>Mena isoforms</th>
<th>Breast cancer cell migration</th>
<th>Breast cancer cell invasion</th>
<th>Breast cancer cell survival</th>
</tr>
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<tbody>
<tr>
<td>Mena1</td>
<td>Increased breast cancer cell migration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mena2</td>
<td>Increased breast cancer cell invasion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mena3</td>
<td>Increased breast cancer cell survival</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Tissue invasion and dissemination**

1. **Primary tumor**
   - Breast cancer cell dissemination to secondary sites.
   - Increased expression of dissemination markers.

2. **Secondary tumor**
   - Breast cancer cell dissemination to distant sites.
   - Increased expression of dissemination markers.