Figure 1. Algorithm for evaluation of human epidermal growth factor receptor 2 (HER2) protein expression by immunohistochemistry (IHC) assay of the invasive component of a breast cancer specimen.

Her2 testing (invasive component) by validated IHC assay

Batch controls and on slide controls show appropriate staining

- Circumferential membrane staining that is complete, intense and in >10% of tumor cells*
  - IHC 3+ positive
  - Must order reflex test (same specimen using ISH) or order a new test (new specimen if available, using IHC or ISH)

- Weak to moderate complete membrane staining observed in >10% of tumor cells
  - IHC 2+ equivocal

- Incomplete membrane staining that is faint/barely perceptible and in >10% of tumor cells
  - IHC 1+ negative

- No staining is observed or Membrane staining that is incomplete and is faint/barely perceptible and in ≤10% of tumor cells
  - IHC 0 negative

NOTE. The final reported results assume that there is no apparent histopathologic discordance observed by the pathologist. Unusual staining patterns of HER2 by IHC can be encountered that are not covered by these definitions. In practice, these patterns are rare and if encountered should be considered IHC 2+ equivocal. As one example, some specific subtypes of breast cancers can show IHC staining that is moderate to intense but incomplete (basolateral or lateral) and can be found to be HER2 amplified. Another example is circumferential membrane IHC staining that is intense but within ≤10% of tumor cells (heterogeneous but very limited in extent). Such cases can be considered 2+ equivocal but additional samples may reveal different percentages of HER2 positive staining. (*)Readily appreciated using a low power objective and observed within a homogeneous and contiguous invasive cell population.
Figure 2. Algorithm for evaluation of human epidermal growth factor receptor 2 (HER2) gene amplification by in situ hybridization (ISH) assay of the invasive component of a breast cancer specimen using a single-signal (HER2 gene) assay (single-probe ISH).

**HER2 testing (invasive component) by validated single-probe ISH assay**

Batch controls and on-slide controls show appropriate hybridization

- **Average HER2 copy number ≥ 6.0 signals/cell**
  - ISH positive
  - Concurrent IHC 3+ and/or Concurrent dual-probe ISH Group 1

- **Average HER2 copy number ≥ 4.0 and < 6.0 signals/cell**
  - Concurrent IHC 2+
  - Perform dual-probe ISH for final result

- **Average HER2 copy number < 4.0 signals/cell**
  - ISH negative
  - Concurrent IHC 0, 1+ and/or Concurrent dual-probe ISH Group 5

**NOTE.** The final reported results assume that there is no apparent histopathologic discordance observed by the pathologist

*It is recommended that concomitant IHC review should become part of the interpretation of single-probe ISH results. The Expert Panel also preferentially recommends the use of dual-probe instead of single-probe ISH assays.

†Using sections from the same tissue samples used for single-probe ISH, perform IHC (if not already done) and/or dual-probe ISH. If IHC results are 2+ equivocal, it is recommended to also perform dual probe ISH.

‡If initial assessment of dual-probe ISH suggestive of Groups 2, 3, or 4, follow the algorithm described in Figure 3.

This algorithm is derived from recommendations in Human Epidermal Growth Factor Receptor 2 Testing in Breast Cancer: American Society of Clinical Oncology/College of American Pathologists Clinical Practice Guideline Focused Update. This is a tool based on an ASCO and CAP guideline and is not intended to substitute for the independent professional judgment of the treating physician. Practice guidelines do not account for individual variation among patients. This tool does not purport to suggest any particular course of medical treatment. Use of the guideline and this tool are voluntary.
**Figure 3.** Algorithm for evaluation of human epidermal growth factor receptor 2 (HER2) gene amplification by in situ hybridization (ISH) assay of the invasive component of a breast cancer specimen using a dual-signal (HER2 gene) assay (dual-probe ISH).

HER2 testing (invasive component) by validated dual-probe ISH assay

Batch controls and on-slide controls show appropriate hybridization

**HER2/CEP17 ratio ≥ 2.0**

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Average HER2 copy number ≥ 4.0 signals/cell</th>
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<tbody>
<tr>
<td>ISH positive</td>
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<table>
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<tr>
<th>Group 2</th>
<th>Average HER2 copy number &lt; 4.0 signals/cell</th>
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<tr>
<td>Additional work-up required (See Fig 4)</td>
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<table>
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<tr>
<th>Group 3</th>
<th>Average HER2 copy number ≥ 6.0 signals/cell</th>
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<tr>
<td>Additional work-up required (See Fig 5)</td>
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<table>
<thead>
<tr>
<th>Group 4</th>
<th>Average HER2 copy number ≥ 4.0 and &lt; 6.0 signals/cell</th>
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</thead>
<tbody>
<tr>
<td>Additional work-up required (See Fig 6)</td>
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<table>
<thead>
<tr>
<th>Group 5</th>
<th>Average HER2 copy number &lt; 4.0 signals/cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISH negative</td>
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</tbody>
</table>

**NOTE.** The final reported results assume that there is no apparent histopathologic discordance observed by the pathologist. Regarding Groups 2, 3, and 4, if not already assessed by the institution/lab performing the ISH test, IHC testing for HER2 should be performed using sections from the same tissue sample used for ISH and the slides from both ISH and IHC be reviewed together to guide the selection of areas to score by ISH (local practice considerations will dictate the best procedure to accomplish this concomitant assessment).

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HER2/CEP17 ratio ≥ 2.0
Average HER2 signals/cell < 4.0

Assess IHC using sections from the same tissue sample used for ISH

IHC 0 or 1+

HER2 Negative with Comment*

IHC 2+

Observer blinded to previous results recounts ISH, counting at least 20 cells

HER2/CEP17 Ratio ≥ 2.0
Average HER2 signals/cell < 4.0

HER2 Negative with Comment*

IHC 3+

HER2 Positive

Other ISH Result

Result should be adjudicated per internal procedures to determine final category

*Comment: Evidence is limited on the efficacy of HER2-targeted therapy in the small subset of cases with HER2/CEP17 ratio ≥2.0 and an average HER2 copy number <4.0/cell. In the first generation of adjuvant trastuzumab trials, patients in this subgroup who were randomized to the trastuzumab arm did not appear to derive an improvement in disease free or overall survival, but there were too few such cases to draw definitive conclusions. IHC expression for HER2 should be used to complement ISH and define HER2 status. If IHC result is not 3+ positive, it is recommended that the specimen be considered HER2 negative because of the low HER2 copy number by ISH and lack of protein overexpression.
**HER2/CEP17 ratio < 2.0**

**Average HER2 signals/cell ≥ 6.0**

Assess IHC using sections from the same tissue sample used for ISH

- **IHC 0 or 1+**
  - HER2 Negative with Comment* (0-1+)

- **IHC 2+**
  - Observer blinded to previous results recounts ISH, counting at least 20 cells
  - 
  - **HER2/CEP17 ratio < 2.0**
  - **Average HER2 signals/cell ≥ 6.0**
  - HER2 Positive

- **Other ISH Result**
  - Result should be adjudicated per internal procedures to determine final category

- **IHC 3+**
  - HER2 Positive

*Comment: There are insufficient data on the efficacy of HER2-targeted therapy in cases with HER2 ratio <2.0 in the absence of protein over-expression because such patients were not eligible for the first generation of adjuvant trastuzumab clinical trials. When concurrent IHC results are negative (0-1+), it is recommended that the specimen be considered HER2 negative.

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**Figure 5. Clinical Question 4 “Group 3”**

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**HER2 Negative with Comment***

*Comment: It is uncertain whether patients with $\geq 4.0$ and $<6.0$ average HER2 signals/cell and HER2/CEP17 ratio $<2.0$ benefit from HER2 targeted therapy in the absence of protein overexpression (IHC 3+). If the specimen test result is close to the ISH ratio threshold for positive, there is a higher likelihood that repeat testing will result in different results by chance alone. Therefore, when IHC results are not 3+ positive, it is recommended that the sample be considered HER2 negative without additional testing on the same specimen.**

**Figure 6. Clinical Question 5 “Group 4”**

HER2/CEP17 ratio $< 2.0$
Average HER2 signals/cell $\geq 4.0$ and $< 6.0$

Assess IHC using sections from the same tissue sample used for ISH

IHC 0/1+

HER2 Negative with Comment*

IHC 2+

Observer blinded to previous results recounts ISH, counting at least 20 cells

HER2/CEP17 ratio $< 2.0$
Average HER2 signals/cell $\geq 4.0$ and $< 6.0$

HER2 Negative with Comment*

Other ISH Result

Result should be adjudicated per internal procedures to determine final category

IHC 3+

HER2 Positive

This algorithm is derived from recommendations in Human Epidermal Growth Factor Receptor 2 Testing in Breast Cancer: American Society of Clinical Oncology/College of American Pathologists Clinical Practice Guideline Focused Update. This is a tool based on an ASCO and CAP guideline and is not intended to substitute for the independent professional judgment of the treating physician. Practice guidelines do not account for individual variation among patients. This tool does not purport to suggest any particular course of medical treatment. Use of the guideline and this tool are voluntary.