

## **Supplementary Methods**

Additional immunohistochemical labeling was performed at the immunohistochemical laboratory of the Department of Pathology of Asan Medical Center. In brief, 4- $\mu$ m tissue sections were deparaffinized and hydrated in xylene and serially diluted ethanol. Endogenous peroxidase was blocked by incubation in 3% H<sub>2</sub>O<sub>2</sub> for 10 minutes, then heat-induced antigen retrieval was performed. Primary antibodies, including cytokeratin 7, cytokeratin 20, CDX2, SMAD4, TTF-1, p63, estrogen receptor, progesterone receptor, and HER2 were used following the manufacturers' protocols with Benchmark autostainers (Ventana Medical Systems, Tucson, AZ). Information of the primary antibodies and dilutions are summarized in S1 Table. Briefly, after applying the primary antibodies, the slides were incubated at room temperature for 32 minutes, then the sections were labeled with an automated immunostaining system using the iView detection kit (Benchmark XT). Immunostained sections were lightly counter-stained with hematoxylin, dehydrated in ethanol, and cleared in xylene.