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It is well known that the solitary waves of the supercritical gKDV equation are linearly unstable. By using the Hamiltonian structure of the linearized gKDV equation, one can show that at each solitary wave, the energy space can be linearly decomposed into unstable space, stable space and center space. Based on the linear decomposition, we construct stable manifolds, unstable manifolds, center-stable manifolds, center-unstable manifolds and center manifolds of the orbits of the whole family of solitary waves. The existence of unstable manifolds implies the nonlinear instability of solitary waves. Beyond instability and stability analysis, these invariant manifolds give a clear picture of the complex dynamics near solitary waves. The construction of these invariant manifolds is nontrivial, because the nonlinearity contains a loss of derivative. (Received September 19, 2016)